

CHAPTER -7

RISK ASSESSMENT

7.1 EXECUTIVE SUMMARY

The industry named M/s. Ishanga Life Science Pvt. Ltd. Industry proposed to Proposed to new project for the manufacturing of Pharma & Intermediate Products to 193 MT/Month located at Survey No.: 310/1/2/3, Madhvas, Tal. Kalol, Dist. Panchmahal- 389330, Gujarat, India.

1.1 Experts from our organization visited the site on **10.01.2019** and subsequently inspection of site as per site plan and the environs along with collection of relevant information about the existing as well as proposed installation. Also a detailed discussion was held on various aspects including storage facilities, process safety and emergency preparedness with the officers of the company.

1.2 Various hazardous chemicals are stored and handled at process area like Acetone, Methanol, Toluene, Ethanol, Bromine, Hydrogen Gas, Nitrogen Gas, Acetic Acid, Acetic Anhydrous, Aceto nitrile, Chloroform, Di chloro methane, EDC, Ethyl acetate, HCL, IPA, Sulfuric Acid, TC, Xylene, THF, MDC, Nitric Acid, Formaldehyde etc. are received through road truck and stored in CCOE approved tank farm area as per Petroleum Act and Rules. Some flammable/combustible liquid/solid chemicals will be received in drums or bags or in carboys, it will be stored in drum storage area and in RM store as per its incompatibility and other properties like flammable, toxic, corrosive and reactive.

1.3 Based on the data furnished and the study of the installation, Hazardous area have been identified and demarked it in red colour line in plant layout figure-2.2 and their consequences are modeled mathematically using DNV-PHAST-8.11 and HAMSGAP software. Mapping of various scenarios are with their hazardous distances and safe distances are drawn on site plan for easy understanding of the consequences of the accident/ incident.

1.4 The study indicates that possible hazards associated with the plant are confined to (a) Tank farm area, (b) Road truck unloading area (c) Drum storage area. (d) Bromine Glass bottle storage area and (e) Hydrogen Cylinder Storage area. Various hazardous scenarios have been identified for Risk Assessment and the consequences modeled.

1.5 Various hazard scenarios have been identified for Risk Assessment and the consequences modeled. The results of the analysis have been summarized in the table appended.

1.6 It is observed from the summary that the consequences of hazards associated with any possible spills / leaks for catastrophic failure of storage tanks, road tanker, and release scenarios would be small in nature and maximum on site effect could be possible and that would be taken care of with the emergency facilities and the manpower deployed at the plant.

1.7 The possibility of occurrence of such hazards and their effects could be further reduced by implementing the suggestions made in this report.

1.8 However considering the potential for hazards, however remote they may be, associated with storage area, some suggestions are made in the subsequent chapters for improvement in the areas of safety, environmental impact, Emergency facilities and emergency preparedness plan at design and commissioning level of proposed additional facilities.

7.2 OBJECTIVE, PHILOSOPHY AND METHODOLOGY OF RISK ASSESSMENT

7.2.1 OBJECTIVE:

The main objectives of the Risk Assessment (RA) study is to determine damage due to major hazards having damage potential to life & property and provide a scientific basis to assess safety level of the facility.

The principle objective of this study was to identify major risks in the manufacture of chemical, agrochemical and intermediates products and storage of hazardous chemical at site and to evaluate on-site & off-site consequences of identified hazard scenarios. Pointers are then given for effective mitigation of hazards in terms of suggestions for effective disaster management, suggesting minimum preventive and protective measures & change of practices to ensure safety.

7.2.2 PHILOSOPHY:

This report is limited to the following:

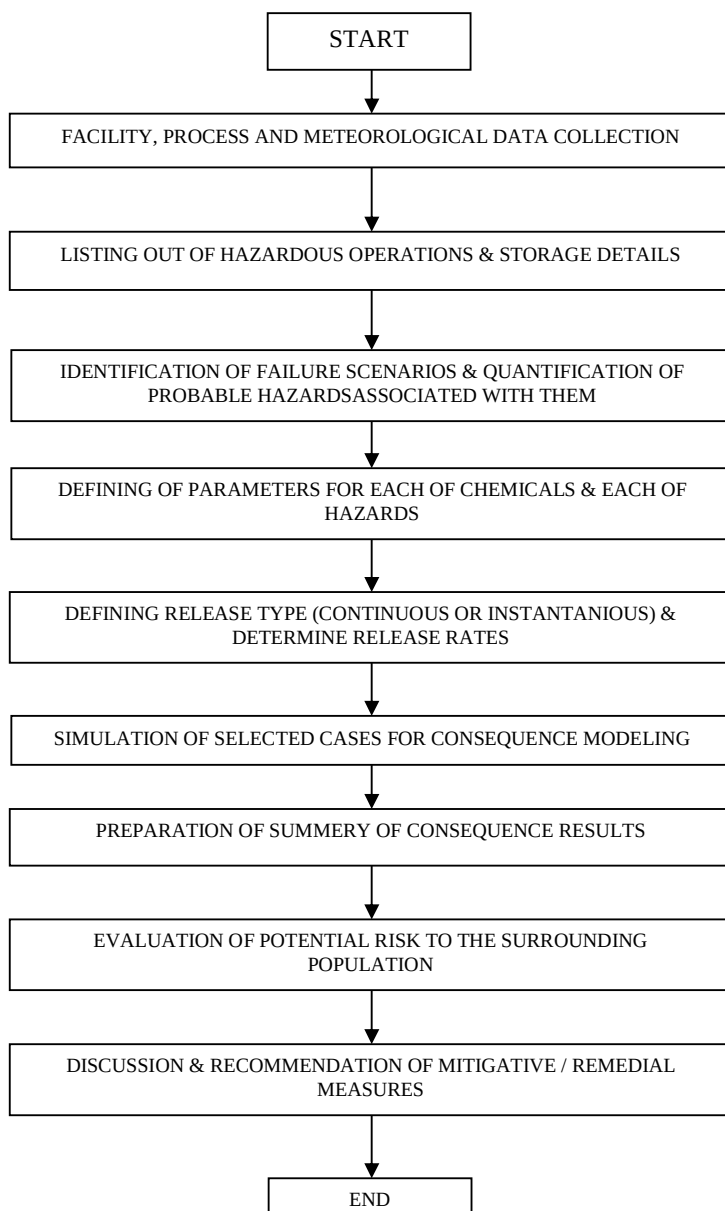
- ❖ Identification of major risk areas.
- ❖ Hazard identification/Identification of failure cases
- ❖ Consequential analysis of probable risks / failure cases
- ❖ Evaluation of heat radiation & pressure wave profiles for identified failure cases
- ❖ Risk assessment on the basis of the above evaluation & risk acceptability
- ❖ Minimum preventive & protective measures to be taken to minimize risks to maximum possible extent.
- ❖ Giving pointers for effective disaster management
- ❖ Suggesting other measures to further lower the probability of risk.

7.2.3 METHODOLOGY

The procedure used for carrying out the Quantitative Risk Assessment Study is outlined below: Identify Credible Loss Scenarios for the facility under the study by discussion with M/s. Ishanga Life Science Pvt. Ltd. Simulate loss Scenarios to determine the vulnerable zones for Jet Fire, toxic dispersion, pool fire, Drum storage area fire, Flash fire, Explosion over pressure, Vapour cloud Explosion, Ball fire using software packages DNV-PHAST-8.11 and HAMSGAP.

Suggest mitigating measures to reduce the damage, considering all aspects of the facilities. The flowchart of the methodology for the present study is shown in following page.

RISK ASSESSMENT STUDY METHODOLOGY FLOWCHART



7.4 PRECAUTION TO BE TAKEN DURING STORAGE

7.4.1 FOR PESO UNDERGROUND STORAGE TANK FARM

- Class A petroleum products will be received through road tanker and stored in underground storage tank as per petroleum rules.
- Tank farm will be constructed as per explosive department requirement and separation distance maintained.
- Static earthing provision will be made for road tanker as well as storage tank.
- Flame arrestor with breather valve will be provided on vent line.
- Road tanker unloading procedure will be prepared and implemented.
- Fire load calculation will be done and as per fire load Hydrant System provided as per NFPA std. and Fire extinguishers will be provided as per fire load calculation.
- Spark arrestor will be provided to all vehicles in side premises.
- Flame proof type equipment s and lighting will be provided.
- Lightning arrestor will be provided on the top of chimney.
- Trained and experience operator will be employed for tank farm area.
- NFPA label (hazard identification) capacity and content will be displayed on storage tank.
- Solvents will be transferred by pump only in plant area and day tank provided. Overflow line return to the storage tank.
- Jumpers will be provided on solvent handling pipe line flanges.
- Flexible SS hose will be used for road tanker unloading purpose.

7.4.2 FOR ABOVE GROUND NON PESO STORAGE TANK FARM

- MS storage tank will be provided as per IS code.
- Dyke wall will be provided to storage tank.
- Level gauge provided with low level high level will be provided.
- Fire hydrant monitor with foam trolley facility will be provided.
- FLP type pump will be provided.
- Double static earthing will be provided to storage tank.
- Double Jumper clip will be provided to all pipeline flanges.
- Road tanker unloading procedure will be prepared and implemented.
- Lightning arrestor, PPEs will be provided.
- Safety shower, eye washer will be provided.
- NFPA labelling system will be adopted for storage tanks.

7.4.3 FOR ACID ALKALI

- Dyke wall will be provided to storage tank Level gauge will provided.
- Scrubber will be provided
- Required PPEs will be provided to all employees
- Double drain valve will be provided to Acid storage tank.
- Full body protection will be provided to operator during unloading and handling of Acids
- Caution note and emergency first aid measures will be displayed and train for the same to all employees.
- Safety shower and eye wash will be provided in storage tank area and plant area.
- Total close process will be adopted for Sulfuric acid handling.

7.4.4 HYDROGENATION PLANT

- FLP type area will be provided.
- Total enclosed process system.
- Instrument & Plant Air System.
- Nitrogen blanketing in Hydrogenation reactor.
- Safety valve and Rupture disc provided on reactor.
- Cooling Chilling and power alternative arrangement have been made on reactor.
- Hydrogen and Nitrogen Cylinder bank away from the autoclave reactor.
- PRV station with shut off valve, safety valve provision will be made for hydrogenation reaction safety.
- Before Hydrogen Gas charging in to reactor and after completion of reaction Nitrogen flushing will be done.
- Flame arrestor will be provided on vent line of reactor and it will be extended up to roof level.
- Open well ventilated and fragile roof will be provided to on reactor.
- Safe Catalyst charging method will be adopted.
- SOP will be prepared and operators will be trained for the same.
- Static earthing and electric earthing (Double) provided.
- Rector vent extended outside the process area and flame arrestor provided on vent line.
- Dumping vessel arrangement will be made.
- Jumpers for static earthing on pipeline flanges of flammable chemical will be provided.

7.4.5 FOR DRUM STORAGE AREA

- Only in general shift material will be being handled.
- FLP type light fittings will be provided.
- Proper ventilation will be provided in godown.
- Proper label and identification board /stickers will be provided in the storage area.
- Drum pallets will be provided.
- Drum handling trolley / stackers will be used for drum handling.
- Separate dispensing room with local exhaust and static earthing provision will be made.
- Materials will be stored as Compatibility and separate area for flammable, corrosive and toxic chemical drums in store.
- Smoking and other spark, flame generating item will be banned from the Gate.

7.4.6 FOR WARE HOUSE SAFETY MEASURES

- FLP type light fittings will be provided.
- Proper ventilation provided will be in godown.
- Proper label and identification board /stickers will be provided in the storage area.
- Separate dispensing room with local exhaust and static earthing provision will be made.
- Materials will be stored as per its compatibility study and separate area made for flammable, corrosive and toxic chemical drums storage.
- Smoking and other spark, flame generating item will be banned from the Gate.

7.4.7 BROMINE BOTTLE STORAGE & HANDLING SAFETY

- The amount of bromine in storage will be kept to a minimum.
- Floors will be of impervious construction, preferably concrete.
- Bromine bottle wooden carriage will be stored on collection pallets
- Area where bromine will be used or stored will be enclosed so that unauthorized persons are prevented from entering the area.
- Personnel escape routes will be clearly marked and it will be maintained without any obstructions including adequately sized doors and windows.
- Facilities like offices, eating, showering and changing rooms, will be located in up wind direction and remote from the area where bromine is handled or stored. Provide an adequate supply of clean water for washing and showers.
- Emergency siren, telephone will be provided in storage area for the reporting of accidents or emergency situations. The emergency telephone numbers will be

displayed at prominent locations and it include the fire department, ambulance service, emergency response team, hospital and police.

- A wind sock will be provided which will clearly visible from all points on the site and replaced as required. This is required for indicating wind strength and direction.
- Emergency respirator equipment cabinets (Cupboard) will be installed not more than 30 meters or 10 seconds walking distance from any location in the storage area.
- Showers and eyewash fountains will be provided, clearly marked, well lit and with unobstructed access.
- Signs will be posted prominently at the site entrance and throughout the installation with area maps showing access ways, hydrant locations, emergency showers, location of emergency equipment and emergency telephone numbers.
- All management and operating personnel involved in the use or handling of bromine will undergo safety training, in addition to specific task training.
- Only experienced well-trained operators will be allowed to handle Bromine.
- Bromine glass bottle capacity 1 liters and six bottles are stored in one packing box.
- Bromine will be stored in dry and cool place and well-ventilated area.
- The driver and assistant driver of any vehicle transporting bromine should comply with the following requirements:
- Open space separated from public highway and public dwellings, where public does not normally pass. No passengers are allowed.
- The driver or driver's assistant may not open a package containing bromine.
- Parking brakes are to be applied whenever parked.
- If the vehicle is parked on a road at night or with poor visibility, warning signs are to be placed 10 meters ahead of and behind the vehicle.
- TREM CARD provided to all transporters and trained for transportation Emergency of Hazardous chemicals.
- American National Standards Institute (ANSI) approved chemical safety goggles at all times when handling Br₂.
- Use a full face shield over eyewear.
- Full body protection PVC suite
- Eyewash fountains should be located in areas where bromine is handled, used or stored.
- When in danger of contact with liquid bromine, wear an approved chemical resistant suit.

- Leather or other non-woven ANSI approved steel-toed shoes or Gum boot
- Protective rubber boots should be worn over shoes for extra protection.
- Have NIOSH approved respirators and self-contained breathing apparatus available.
- Gloves: 100% Nitrile rubber gloves or Neoprene gloves.

Safety Practices in the Work Area

- We will inform our all employees of the potential hazards of contact with bromine and train them in appropriate first-aid procedures.
- Bromine handling areas will be clearly marked and restricted to qualified, trained personnel only.

Ventilation

We will maintain bromine vapor concentration in the work area to less than 0.1 ppm with adequate exhaust hoods, ventilation systems and scrubbers. Analyze air for proper control.

- Transfer or repackage bromine only in a controlled, closed environment.
- Exhaust ventilating systems will be used in enclosed areas where bromine is handled.

Storage

- Bromine glass bottle capacity 1 liters and six bottles are stored in one packing box.
- Bromine will be stored in dry and cool place and well-ventilated area.
- Neutralization in case of spillage leakage.
- Neutralization with sodium bisulfite requires 3 moles of sodium hydroxide: 1 mole sodium bisulfite: 1 mole bromine.
- Neutralization with sodium sulfite requires 2 moles sodium hydroxide: 1 mole sodium sulfite: 1 mole bromine.
- The weights and volumes specified include a 10% excess of sodium hydroxide and sodium bisulfate or sodium sulfite.

Emergency Procedures

In case of bromine emergencies, follow recommended first aid and emergency response procedures adopted.

Transportation Emergencies

In emergency situations resulting from vehicle accidents:

- Notify the local police, fire departments, emergency responders and the carrier.
- Isolate the area.
- Any person not dressed in proper protective clothing and not using a NIOSH approved self-contained breathing apparatus should be kept a safe distance away.
- Call to the supplier

- Seek immediate medical assistance for those injured and follow recommended first aid procedures.

Leaking Containers

- When handling a leaking bottle personal protective clothing, goggles and NIOSH approved self-contained breathing equipment must be worn.
- Clear contaminated area of non-essential personnel and send them to assembly point.
- Maintain a slight ammonia atmosphere throughout the clean-up. Carefully release anhydrous ammonia gas to neutralize bromine vapor. The ammonia gas will convert bromine to white ammonium bromide “smoke.”
- Do not allow liquid bromine and liquid ammonia to combine; a violent reaction will occur. Ammonia (16 to 25% by volume) can form an explosive mixture with air.
- Pour hypo solution*, lime and water slurry or soda ash solution over the spill. Hypo-bromine reactions produce Hydrobromic acid.
- Dry sodium thiosulfate and liquid bromine produce a violent reaction; do not mix them.
- Using cold water, wash neutralized bromine into a sump for transfer to an approved waste disposal facility where the waste can be processed.
- Ventilate the area to remove the ammonium bromide and any bromine fumes. Scrub the floors and equipment with soap and water.

First Aid Procedure

- Immediate medical assistance is required if bromine is swallowed, inhaled or has contacted the eyes or skin.
- If bromine has been ingested, do not give anything by mouth. Seek medical attention immediately. Do not induce vomiting.
- If bromine has been inhaled, move the exposed person to a well-ventilated area. Seek medical attention immediately. The victim should be placed in a comfortable sitting or partly reclining position. The exposed individual should avoid exertion. If vomiting occurs, turn the patient on his side to avoid choking. Keep the patient warm. If the patient is coughing and showing signs of respiratory distress, properly trained personnel should administer oxygen.
- For skin contact, the affected area must be flooded immediately with large amounts of clean water from a safety shower or other appropriate source of flowing water. Seek medical attention immediately. All contaminated clothing, including shoes, should be removed as quickly as possible while the victim is under the shower. Washing should

be continued for a minimum of 30 minutes. If possible, continue to wash the affected area during transport to medical facilities. (Extended wash times of two hours or more have proven beneficial.)

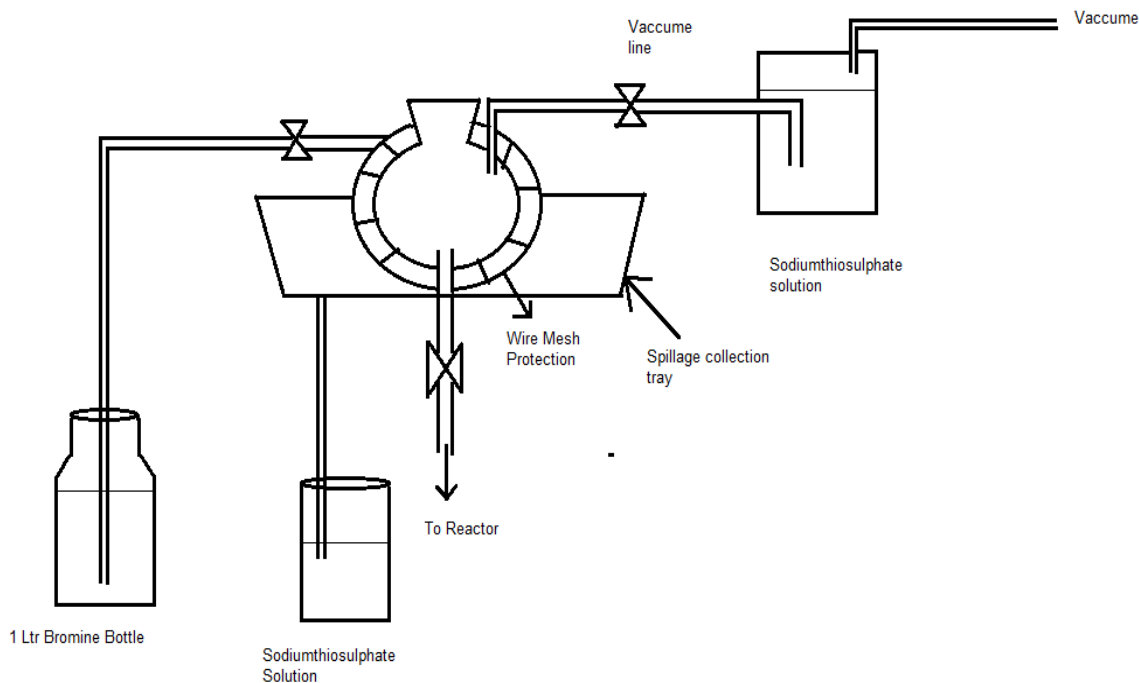
Bromine charging procedure:

Following procedure will be adopted while Bromine glass bottle in reactor:

- Full body protection with airline respirator suite will be provided to operator.
- Airline respirator will be used for bromine charging
- Bottle will be charged in to glass flask by vacuum and from glass flask will be charged in to reactor by gravity gradually.

FIGURE: 7.2

DIAGRAM FOR BROMINE HANDLING



7.5 HAZARDOUS PROPERTIES OF THE CHEMICALS, COMPATIBILITIES AND SPECIAL HAZARD

TABLE 7.2

HAZARDOUS PROPERTIES OF THE CHEMICALS, COMPATIBILITIES AND SPECIAL HAZARD

Sr. No.	Name Of Chemical	Hazard	Flash Point °C	Bp °C	LEL %	UEL %	Sp.Gr . 20 °C	Vd	Solubility With Water At 20 °C	Nfpa H F R	Hazardous Combustion Product	Tlv Pp m	Idlh Ppm	Lc50 Mg/M3	Target Organs	Carcinogenicity	Antidote
1.	Acetone CAS# 67-64-1	F	- 20	56	2.15	13.0	0.791	2.00	Soluble	1 3 0	Irritating vapour	750	25000 LEL	NA	Eye , Skin	No	10 mg diazepam through injection
2.	Methanol CAS# 67-56-1	F/ T	10	54	5.4	44	0.792	1.1	Soluble	1 3 0	Irritating vapour	200	6000 LEL	64000 ppm for 4H rat	Kidneys, heart, central nervous system, liver, eyes	No	10 mg diazepam through injection Activated Charcoal
3.	Toluene CAS # 108-88-3	F	4.0	111	1.1	7.1	0.87	3.2	Insoluble	2 3 0	Irritating Vapour generated	50	2000	400 ppm for 24Hr Rat	Eyes, skin, respiratory system, central nervous system, liver, kidneys	No	Diazem – 1 mg/Kg. (Intravenous), Epinephrine, Efidrine

Sr. No.	Name Of Chemical	Hazard	Flash Point °C	Bp °C	LEL %	UEL %	Sp.Gr . 20 °C	Vd	Solubility With Water At 20 °C	Nfpa H F R	Hazardous Combustion Product	Tlv Pp m	Idlh Ppm	Lc50 Mg/M3	Target Organs	Carcinog-Enicity	Antidote
4.	Bromine CAS #7726-95-6	C/ T	NF	58.78	NA	NA	3.11	7.1	Soluble in water	3 0 0	Non combustible	0.2 pp m	3.0 ppm	2600 mg/kg [Rat	Eye , Skin	No	give milk, butter-milk or lemon juice or make a small cotton ball and drench with ethanol or ether solution drops and put it near victim's nose for smell. Apply pure oxygen.
5.	Hydrogen Gas CAS # 1333-74-0	F/ E	N.A .	- 252 .8° C	3.0	74	0.0696	NA	Soluble in water	1 4 0	Explosive gas	250 pp m	NA	LC50 >800000 ppm rat	lungs, heart, upper respiratory tract, central nervous system (CNS)	No	No specific Antidote
6.	Nitrogen Gas CAS # 7727-37-9	T	NA	- 195	NA	NA	NA	NA	NA	3 0 0	NA	N. A.	N.A.	N.A.	Eye , Skin, lungs, heart	No	No specific Antidote
7.	Acetic anhydride CAS No.108-24-7	F/ T	49	140	2.7	10.3	1.05	3.5	Slightl y	3 2 1	Emits toxic fumes	5p pm	200 ppm	1780 mg/m3	eyes, skin, respiratory system, lungs	No	milk butter and milk of magnesia.

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Sr. No.	Name Of Chemical	Hazard	Flash Point °C	Bp °C	LEL %	UEL %	Sp.Gr . 20 °C	Vd	Solubility With Water At 20 °C	Nfpa H F R	Hazardous Combustion Product	Tlv Pp m	Idlh Ppm	Lc50 Mg/M3	Target Organs	Carcinog-Enicity	Antidote
8.	Acetic Acid CAS No. 64-19-7	T / F	44.4	117.9	5.4	16.0	1.015	2.1	Soluble	2 2 1	Irritating Vapour generated	10 ppm	50 ppm	5620 ppm/1H	Teeth, eyes, skin, mucous membranes	No	Milk of magnesia.
9.	Chloroform CAS # 7-66-3	T	NF	61.2	NF	NF	1.49	4.1	Insoluble	2 0 0	N A	10 ppm	500 ppm	47702 mg/m 4 hrs rat	Eye , Skin	Yes	Amyl nitrite or ammonia.
10.	Dichloro Methane (MDC, DCM) CAS#: 75-09-2	T	N.F	39.8	14.0	22.0	1.325	2.9	20 g/ lit.	2 0 1	CO, CO2, Cocl2, HCL (g) generated	50		52 gm/m3 inhalation - rat	blood, central nervous system	Yes	no specific antidote.
11.	Ethylene Dichloride (EDC CAS #107-06-2)	F/t	13	83	6.2	15.9	1.253	3.4	0.87 %	2 3 1	Hcl, Phosgene	10	50	N.L	eyes, skin	Yes	N.A.
12.	Formaldehyde 50-00-0	F/ T	60	96	7.0	73.0	1.08	1.04	MISCIBLE	3 2 0	Irritating toxic Gas generated	0.1	20 ppm	203 mg /M3	Skin, Eye	No	Milk, Activated Charcoal or water

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13.	Hydrochloric Acid HCL CAS#: 7647-01-0	C/ T	NF	108	NF	NF	1.12 - 1.19	1.267	Soluble	3 0 1	N A	5 ppm	50 ppm	3124 ppm for 1h rat	Kidney, liver, mucous membranes, respiratory system, skin, eyes and cardiovascular system	No	Sodium Hydro-Carbonate (4% Conc.)
14.	Isopropyl alcohol(IPA) CAS # 67-63-0	F	18.5	82.3	2.3	12.7	0.785	2.1	Miscible	1 3 0	Acid smoke & fumes	400	2000 LEL	NA	NA	No	No specific Antidote
15.	Hexane CAS #110-54-3	F	-7	68.7	1.2	7.7	0.659	3.0	Insoluble	1 3 0	CO & CO2	500	1100	48000 ppm (Rat) 4 h	Eyes, skin, respiratory system, central nervous system, peripheral nervous system	No	No specific Antidot
16.	Nitric Acid CAS # 7697-37-2	C	NF	121	NA	NA	1.408	2.5	Soluble	3 0 0	Non combustible	4	67 ppm (NO2)/ 4H.	260 mg/m3/30M Rat	Lungs, eyes, skin, mucous membranes.	Yes	Sodium Hydro-Carbonate (4% Conc.), Milk, Lime Juice, Milk of Megnesia

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17.	Pyridine CAS # 110 – 86 - 1	F	19	115 ..3	1.8	12.4	0.983	2.73	Soluble	2 3 0	Irritating vapour	5 PP M	1000	Not available	Skin, eyes	No	No specific Antidote
18.	Sulfuric Acid CAS # 7664-93-9	C	NA	340	NA	NA	1.84	NA	Water reactive	3 0 2	Non combustible	1 mg /m 3	15 mg/m ³	510 Rat	Eyes, skin, respiratory system, teeth	No	Sodium Hydro-Carbonate (4% Conc.), Milk, Lime Juice, Milk of Megnesia
19.	Thionyl Chloride CAS # 771909-7	 NF	NF	76	1.64	4.6	NA	NA	Water reactive	4 0 2	sulfur dioxide, sulfur chloride	1 pp m	Not determined	500 ppm for 1 Hr Rat	Skin, eyes, Lung	No	natural oil and one table spoon sodium or magnesium sulphate with one glass of water.
20.	Xylene CAS # 1330-20-7	F	31	143 - 145	1.7	7.6	0.878	3.7	0.2 g/l	3 2 0	CO ₂ , CO	100 pp m	150 ppm	4550 ppm 4 hour(s) [Rat].	Eyes, skin,	No	Diazem – 1 mg/Kg. (Intravenous), Epinephrine, Efidrine
21.	Ammonia liquor CAS #1336-21-6	Toxic	NF	36	16	25	0.9	1.2	Miscible	3 1 0	Not combustible	25	300	2000 ppm/4-hr	Skin, Eye, respiratory system.	No	Wash with Lactic Acid, Apply soframycin Smelling Ethanol or Ether

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22.	Activated charcoal or carbon CAS#: 7440-44-0	F	NA	NA	NA	NA	1.07	0.62	Insoluble	1 3 0	ammonium nitrate, NA2s	NA	NA	NA	No	No	No specific Antidote
23.	Aluminum Chloride alcl3 CAS #7446-70-0	C/ T	NF	NA	NA	NA	2.44	4.5	NA	3 0 2	Toxic fumes	5 ppm	100 ppm	1274 PPM	Eye , Skin	No	2 to 5 gm thiosulphate in 5% sodium bicarbonate solution in 200 ml
24.	Benzoic Acid	T	121	249.2	N/A	N/A	1.2659	4.2	slightly soluble	2 1 0	CO, CO2	N/A	N/A	N/A	Eye , Skin	NO	No specific Antidote
25.	Benzyl chloride CAS#100-44-7	H/ F	67	179	1.1	14	1.1	4.4	NA	3 2 1	NA	1	10 ppm	LC50: Acute: 1870 mg/m32 hours [Rat].	Eyes, skin, respirator system	YES	Epikake solution, activated charcoal, milk Homeopathy Antidote Benzyl Chloride
26.	Calcium Carbonate CAS#: 471-34-1	C	N.A	N. A.	N.A	N.A	2.8	N.A	Soluble	1 0 0	N.A.	500.0 mg/m3	N.A.	N.A.	Eye , Skin	No	No specific Antidote

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27.	Calcium Chloride CAS#: 10043-52-4	T/ C	N.A .	1670	N.A .	N.A .	2.15	N.A .	Soluble	2 0 2	N.A.	400 .0 mg/ m3	N.A.	100 mg/1 96 hours [Fish]	Eye , Skin	No	No specific Antidote
28.	Dimethyl Sulfoxide DMSO CAS#: 67-68-5	T	95	189	3.0	63.0	1.101	2.71	Soluble	1 1 0	SO2, Fomaldehyde, Mercaptan	N.L .	N.L.	N.A.	Eye , Skin	No	N.A.
29.	Hydrogen peroxide	T/ C	N/F	1-8	NF	NF	1.1	1.1	yes	2 0 1	Explosion due to hydrogen	1	NA	70.17 rat	NA	No	No specific Antidote
30.	Raney nickel	T/ F	NA	NA	NA	NA	NA	NA	In contact with water releases flammable gas	3 2 0 W	obnoxious and toxic fumes	1	5	NA ATE > 20 mg/l.	Skin.	Yes Nickel is Group 2B carcinogen - IARC	No specific antidote

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Sr. No.	Name Of Chemical	Hazard	Flash Point °C	Bp °C	LEL %	UEL %	Sp.Gr . 20 °C	Vd	Solubility With Water At 20 °C	Nfpa H F R	Hazardous Combustion Product	Tlv Pp m	Idlh Ppm	Lc50 Mg/M3	Target Organs	Carcinogenicity	Antidote
31.	Sodium Bicarbonate CAS# 144-55-8	T	N.A	100	N.A	N.A	1.06	0.62	Soluble in water	1 0 0	N.A	N. A	N.A	(LD50): 81800 mg/kg (Rat	Eyes, skin, respiratory system	No	No specific antidote
32.	Sodium Carbonate Solution	C	NA	NA	NA	NA	2.53	NA	Soluble	1 0 1	NA	N. A.	N.A.	2300 ppm	Eyes, skin,	No	No specific antidote
33.	Sodium cyanide NaCN CAS #143-33-9	H	NF	Very high	NF	NF	1.60	NA	Soluble	3 0 0	Irritating vapor	5 mg/m3	25 mg/m3	NA	Eye & Skin	No	Methelene Blue or Kelocynere injection
34.	Trimethylamine (TMA) CAS#: 75-50-3	T/F	- 6.1 5	2.9	2.0	11.6	0.633	2.0	Insoluble	3 4 0	NP	5	NL	2000 1 hr Rat	Respiratory system, eyes, skin, mucous membranes	No	Not available
35.	Urea	T	NA	NA	NA	NA	1.323	2.0 7	Easily Soluble	2 1 0	CO ₂ , CO, NO _x	NA	N/A	4241 mg/l	Eyes, skin	NO	No specific Antidote

F = FIRE

LEL = LOWER EXPLOSIVE LIMIT

SP.GR = SPECIFIC GRAVITY

R = REACTIVE HAZARD

T = TOXIC

UEL= UPPER EXPLOSIVE LIMIT

BP= BOILING POINT

BR = BURNING RATE

E= EXPLOSIVE

STEL = SHORT TERM EXPOSURE LIMIT

PPM = PARTS PER MILLION

H = HEALTH HAZARD CLASS

R = REACTIVE

E = EVAPORATION RATE

VD= VAPOUR DENSITY

F = FIRE HAZARD CLASS

C = CORROSIVE

TLV = THRESHOLD LIMIT VALUE

NFPA =NATIONAL FIRE PROTECTION ASSOCIATION-usa

N.A. = NOT AVAILABLE

N.L. = NOT LISTED

7.6 TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE

7.6.1 FOR ACETONE, METHANOL, TOLUENE, ETHANOL

TABLE 7.3

TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE WILL BE DONE FOR ACETONE, METHANOL, TOLUENE, ETHANOL

SR. NO.	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
1	Transportation of Solvents like n-Acetone, Methanol, Toluene, Ethanol etc. by road tanker.	Leakage, Spillage, fire, explosion, Toxic release	• Training –will be provided to driver and cleaner regarding the safe driving, hazard of Flammable chemicals, emergency handling, use of SCBA sets. • TREM card will kept with TL. • SCBA set will kept with TL. • Fire extinguishers will kept with TL. • Flame arrestor will be provided to TL exhaust. • Instructions will given not to stop road tanker in populated area. • Clear Hazard Identification symbol and emergency telephone number will displayed as per HAZCHEM CODE. • Appropriate PPEs will kept with TL.
2	Acetone, Methanol, Toluene, Ethanol etc Road tanker unloading at Hemali site.	Leakage, Spillage, fire, explosion, toxic release	• Priority will given to Tanker to immediately enter the storage premises at site and will not be kept waiting near the gate or the main road. • Security person will check Licence, TREM CARD, Fire extinguisher condition, SCBA set condition, Antidote Kit, required PPEs as per SOP laid down. • Store officer will take sample as per sampling SOP from sampling point. • After approval of QC department unloading procedure - allowed be started. Following precautions - adopted during unloading

SR. NO.	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
			• Wheel stopper will provided to TL at unloading platform. • Static earthing will be provided to road tanker. • Tanker unloading procedure will be followed according to check list and implemented. • Flexible SS hose connection will be done at TL outlet line. • The quantity remaining in the hose pipeline will be drained to a small underground storage tank, which - subsequently transferred by nitrogen pressure to the main storage tank thus ensuring complete closed conditions for transfer from road tanker. • All TL valves will be closed in TL. • Finally earthing connection and wheel stopper will be removed. • Only day time unloading will be permitted.
3	Acetone, Methanol, Toluene, Ethanol etc Storage tank safety	Leakage, Spillage, Fire, Explosion, Toxic release.	• SS storage tank will be provided as per IS code. • Dyke wall will be provided to storage tank. • Level transmitter will be provided with low level high level auto cut-off provision. • Vent will be connected to water trap and vent of water trap - provided with flame arrestor. • Water sprinkler system will be provided to storage tank. • Fire hydrant monitor with foam attachment facility will be provided. • Dumping / Drain vessel/alternate vessel will be provided to collect dyke wall spillage material. • FLP type pump will be provided.

SR. NO.	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
			• Nitrogen blanketing will be provided to storage tank. • Double static earthing will be provided to storage tank. • Double Jumper clip will be provided to all Solvent handling pipeline flanges.
4	Acetone, Methanol, Toluene, Ethanol etc transfer from storage tank to Day tank	Leakage, Spillage due to Line rupture, Flange Gasket failure, Fire, Explosion, Toxic release.	• Double mechanical seal type FLP type pump will be provided. • Double on / off switch will provided at tank farm and process area near day tank. Pump auto cut off with day tank high level • Flame arrestor will be provided on day tank vent. • Over flow will be provided for additional safety and it - connected to main storage tank. • NRV will be provided on pump discharge line. • Double Jumper clip will be provided to all solvent handling pipeline. • Double static earthing will be provided to day tank.
5	Acetone, Methanol, Toluene, Ethanol etc transfer from Day tank to reactor.	Leakage, Spillage due to Line rupture, Flange Gasket failure, Fire, Explosion, Toxic release.	• Gravity transfer will be done. • Total quantity of day tank material will be charged in to reactor at a time. • NRV will be provided on day tank outlet line. • Static earthing will be provided to storage tank. • Double Jumpers will be provided to pipeline flanges.

7.6.1 DRUMS TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE

TABLE 7.4

DRUMS TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE

SR. NO.	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
1	Transportation of drums	Leakage, Spillage, fire, explosion, Toxic release	• Training will be provided to driver and cleaner regarding the safe driving, hazard of Flammable chemicals, emergency handling, use of SCBA sets. • TREM card will kept with TL. • SCBA set will be kept with TL. • Fire extinguishers will be kept with TL. • Flame arrestor will be provided to TL exhaust. • Instructions will be given not to stop road tanker in populated area. • Clear Hazard Identification symbol and emergency telephone number will be displayed as per HAZCHEM CODE. • Appropriate PPEs will be kept with TL.
2	Drums unloading at site.	Leakage, Spillage, fire, explosion, toxic release	• Priority will be given to truck to immediately enter the storage premises at site and will not be kept waiting near the gate or the main road. • Security person will check Licence, TREM CARD, Fire extinguisher condition; SCBA set condition, Antidote Kit, required PPEs as per SOP laid down. • Store officer will take sample as per sampling SOP from sampling point. • After approval of QC department unloading procedure will be allowed be started following precautions will be adopted during unloading • Wheel stopper will be provided to TL at unloading platform. • Only day time unloading will be permitted.

SR. NO.	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
3	Godown / warehouse safety	Leakage, Spillage, Fire, Explosion, Toxic release.	• FLP type light fittings will be provided. • Proper ventilation will be provided in godown. • Proper label and identification board /stickers will be provided in the storage area. • Conductive drum pallets will be provided. • Drum handling trolley / stackers/fork lift will be used for drum handling. • Separate dispensing room with local exhaust and static earthing provision will be made. • Materials will be stored as per its compatibility study and separate area will be made for flammable, corrosive and toxic chemical drums storage. • Smoking and other spark, flame generating item will be banned from the Gate.
4	Acids, Solvents etc. transfer from drum to Day tank/ reactor	Leakage, Spillage due to Line rupture, Flange Gasket failure, Fire, Explosion, Toxic release.	• Acids and solvents transfer by vacuum or by pump only. • Static earthing will be provided. • SS flexible hose / conductive hose will be used.
5	Acids, Solvents etc transfer from Day tank to reactor.	Leakage, Spillage due to Line rupture, Flange Gasket failure, Fire, Explosion, Toxic release.	• Gravity transfer. • Total quantity of day tank material will be charged in to reactor at a time. • NRV will be provided on day tank outlet line. • Static earthing will be provided to storage tank. • Double Jumpers will be provided to pipeline flanges.

7.6.2 BROMINE TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE

TABLE 7.5

BROMINE TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE			
SR. NO	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
1	Transportation of Bromine Pack of six 3 Kg glass bottle in wooden case	Leakage, Spillage, Toxic release	• GPS will be installed in all the trucks/road tanker and vehicle. • Driver and assistant will be trained in using GPS. • Open space separated from public highway and public dwellings, where public does not normally pass. No passengers are allowed. • The crew shall know how to use fire-fighting appliances. • The driver or driver's assistant may not open a package containing bromine. • Bromine receptacles are not to be checked with open flames. • No smoking is permitted around the transport unit or in the vicinity of the vehicle during handling operations. • The engine is to be shut off during all handling operations unless required to drive pumps, hoist, etc. • Parking brakes are to be applied whenever parked. • If the vehicle is parked on a road at night or with poor visibility, warning signs are to be placed 10 meters ahead of and behind the vehicle.

SR. NO	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
			• TREM CARD provided to all transporters and trained for transportation Emergency of Hazardous chemicals. • All trucks having 1 kg Sodium Thiosulfate bag. • Training will be provided to driver and cleaner regarding the safe driving, hazard of Bromine emergency handling, use of SCBA sets and neutralizing agent. • SCBA set will be kept with ISO container truck. • All the ISO container truck will be equipped with Global Positioning system (GPS) and route will be predefined. • Clear Hazard Identification symbol and emergency telephone number will be displayed as per HAZCHEM CODE. • Appropriate PPEs will be kept with Truck.
2	Bromine ISO container loading and handling at site	Leakage, Spillage, fire, explosion, toxic release	• Road Tanker / truck will be placed at storage area and connected with process tank. • Wear recommended personal protective equipment during connection of ISO container. • Make sure the absorber unit is working and capable of handling vented bromine fumes. • There would be sufficient bromine storage tank capacity or an empty ISO tank to

SR. NO	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
			accommodate the transfer of bromine from a leaking container • Area where bromine will be used or stored will be enclosed so that unauthorized persons and animals are prevented from entering the area. Adequate lighting will be provided to allow sufficient night surveillance. Surveillance will be provided 24 hours a day. • Personnel escape routes will be clearly marked and it will be maintained without any obstructions including adequately sized doors and windows. • Facilities like offices, eating, showering and changing rooms, will be located in up wind direction and remote from the area where bromine is handled or stored. Provide an adequate supply of clean water for washing and showers. • Emergency siren, telephone will be provided in storage area for the reporting of accidents or emergency situations. The emergency telephone numbers will be displayed at prominent locations and it include the fire department, ambulance service, emergency response team, hospital and police. • A wind sock will be provided which will clearly visible from all points on the site and replaced as required. This is required for indicating wind strength and direction.

SR. NO	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
			• Emergency respirator equipment cabinets(Cupboard) will be installed not more than 30 meters or ten seconds walking distance from any location in the storage area. • Showers and eyewash fountains will be provided, clearly marked, well lit and with unobstructed access. • Signs will be posted prominently at the site entrance and throughout the installation with area maps showing access ways, hydrant locations, emergency showers, location of emergency equipment and emergency telephone numbers. • All management and operating personnel involved in the use or handling of bromine will undergo safety training, in addition to specific task training. • Only experienced well-trained operators will be allowed to receive and unload bromine receptacles. • The management will ensure that emergency response plans have been made and coordinated with the emergency response local authorities. • Safety permit for hazardous material loading unloading will be prepared and implemented. • Fire hydrant system and water sprinkler system installed at tank farm area.

7.6.3 SODIUM CYANIDE TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE

TABLE 7.6

SODIUM CYANIDE TRANSPORTATION, UNLOADING AND HANDLING PROCEDURE

SR.NO.	ACTIVITY	TYPE OF POSSIBLE HAZARD	PROCEDURES.
1	Transportation of Sodium Cyanide by road truck	Leakage, Spillage, Toxic release in case of direct contact or ingestion	• Close pack HDPE drums with seal. • No hazard during transportation due to solid pallets.
2	NACN storage and handling safety	Leakage, Spillage, Toxic release in case of direct contact or ingestion	• Separate stored in locked room. • Away from water sources. • Total body protection suite will be provided to charging operator with airline respirator. • Safe operating (Charging) procedure will be prepared and displayed in process and storage area. • Total close process for charging and handling. • Antidote kit for cyanide will be kept ready in OHC. • Training is being provided to handle NACN, • SCBA sets are available in handling area.

7.7 FIRE PREVENTION & PROTECTION SYSTEM**TABLE: 7.7****FIRE PROTECTION SYSTEM**

Protection System		Details		
Department wise List of fire extinguishers with mapping if available		Fire Extinguisher will be provided throughout the plant.		
Fire hydrant system		Fire hydrant system will be installed.		
Area / Plant	Hydrant Post Number	Hose Box Number	Nos. Of Monitors	
Total	20	20 Nos.	05 Nos.	
Proposed Details of Fire Water Pump				
Pump Detail	Number of Pump	Head	Capacity (Flow) M3/Hr	KW/HP
Electrical driven pump	1	70 m	171 Cum/Hr / 2850 LPM / 47.5 LPS	56kw / 75 HP 2900 RPM @ 7 kg/cm2 Flow
Diesel	1	70 m	171 Cum/Hr / 2850 LPM / 47.5 LPS	4R1040T, 85 HP / 1800 RPM Radiator Cooled
Jockey pump	1	70 m	10.8 m3/hr / 180 LPM / 3 LPS	7.5KW / 10 HP 2900 RPM @ 7 kg/cm2 Flow
Total	3			
Fire and safety team		Will be prepared and trained for the same activities.		
Smoke detectors and gas detectors		Smoke detectors and gas detectors (LEL % based) will be installed in drum storage area and tank area.		
Nearest fire station		GIDC fire station 1 km. away from the site and fire tender reach time maximum 10 minutes		
Fire prevention		Flame proof electrical equipments will be provided in process and storage area. Gas detectors will be provided in drum storage area.		
Environment control plan.		Total close process will be adopted for process. Vent condenser and scrubber will be provided for toxic gas/vapour emission control. Loose handling of any chemicals will be restricted and spill control plan will be prepared.		

TABLE: 7.8**FIRE EXTINGUISHER TYPE**

Fire Extinguisher Type	Capacity
Mechanical Foam type 50 Ltr. Cap.	05 Nos.
CO ₂ type 4.5 Kgs.	05 Nos.
ABC type 9.0 Kgs.	30 Nos.
ABC type 6.0 Kgs	10 Nos.

7.8 DETAILS OF OCCUPATIONAL HEALTH PROGRAM

i) To which chemicals, workers are exposed directly or indirectly. Provided in below table-7.9 column B.

ii) Whether these chemicals are within Threshold Limit Values (TLV)/ Permissible Exposure Levels as per ACGIH recommendation.

Yes, regular Work place monitoring carried out and checked where it is in TLV limit or not. If required control measures to be provided to control under TLV limit.

iii) What measures company has taken to keep these chemicals within PEL/TLV?

Measures to keep exposure below TLV/ PEL are provided in below table 7.9 column D.

iv) How the workers are evaluated concerning their exposure to chemicals during replacement and periodical medical monitoring.

Premedical examination and periodical medical examination is carried out once in a year and record maintained in Form No-32 & 33.

v) What are onsite and offsite emergency plan during chemical disaster. Onsite and offsite emergency plan provided in Table-7.9 column E

vi) Liver Function Tests (LFT) during pre-placement and periodical examination.

LFT will be done those workers who are working in process area and record will be maintained.

vii) Details of occupational health surveillance programme.

- In process there is no any high noise, high heat stress and low level illumination exposure to workers.
- Manual material handling only the causes of musculo-skeletal disorders (MSD), backache, pain in minor and major joints, fatigue etc. following measure have been taken to avoid above mentioned ill health effect to workers.
- Below 25 kgs weight will be handling by a worker if required to do so.
- Material handling lorry-cart, drum handling trolley, fork lift, stacker, etc. will be used for material handling.
- Training will be carried out for Manual material handling.
- Ergonomics study will be carried out before commissioning of the plant and correct material flow, Process flow of work place will be designed.

Following activities will be carried out for Occupational health of the workers.

- Treatment part (OPD) for both company and contractor employees.
- Occupational related problems will be studied like ergonomic issues and control measures.
- Prevention part- Pre medical examination and periodical medical examination for operators, helpers, chemists.
- Profile active (Health Awareness programme)

7.9 OCCUPATIONAL HEALTH IMPACT ON EMPLOYEES, CONTROL MEASURES, ACTION PLAN IF ACCIDENT OCCUR AND ITS ANTIDOTES

TABLE 7.9

OCCUPATIONAL HEALTH IMPACT ON EMPLOYEES, CONTROL MEASURES, ACTION PLAN IF ACCIDENT OCCUR AND ITS ANTIDOTES

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
A	B	C	D	E
1.	Hexane CAS # 110-54-3	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
2.	n- Butanol CAS # 71-36-3	Repeated or prolonged exposure is not known to aggravate medical condition	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective Threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a concentration level above TLV.
3.	Formaldehyde 50-00-0	The substance may be toxic to kidneys, liver, skin, central nervous system (CNS). Repeated or prolonged exposure to the	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective	Flammable liquid. Poisonous liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		substance can produce target organs damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.	threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.	combustible material. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV.
4.	Bromine CAS # 7726-95-6	The substance may be toxic to kidneys, liver, cardiovascular system, central nervous system (CNS), thyroid. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection. Repeated exposure to a highly toxic material may produce general deterioration of health by an	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location	Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV.

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		accumulation in one or many human organs.		
5.	Formic acid 64-18-6	The substance may be toxic to kidneys, liver, upper p. 2 respiratory tract, skin, eyes, central nervous system (CNS). Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection.	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective Threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.	Combustible material. Corrosive liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above TLV
6.	Isopropyl acetate (d=0.88)	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
7.	Thionyl Chloride CAS # 771909-7	Corrosive. Extremely destructive to tissues of the mucous membranes and upper respiratory tract. Symptoms	Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels below	Do not contact with water. Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting. Inhalation may be fatal as a result of spasm inflammation and edema of the larynx and bronchi, chemical pneumonitis and pulmonary edema. Prolonged or repeated exposure may cause conjunctivitis, dermatitis, rhinitis, and pneumonitis.	recommended exposure limits. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use only under a chemical fume hood.	unprotected personnel from entering. Contain and recover liquid when possible. Neutralize with alkaline material (soda ash, lime), then absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer!
8.	Hydrogen peroxide	Very hazardous in case of skin contact (irritant), of eye contact (irritant). Hazardous in case of skin contact (corrosive), of eye contact (corrosive), of ingestion, . Slightly hazardous in case of inhalation (lung sensitizer). The substance is toxic to lungs, mucous membranes	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location. Use PPEs.	EXPLOSION HAZARD: SEVERE, WHEN HIGHLY CONCENTRATED OR PURE H ₂ O ₂ IS EXPOSED TO HEAT, MECHANICAL IMPACT, OR CAUSED TO DECOMPOSE CATALYTICALLY BY METALS & THEIR SALTS, DUSTS & ALKALIES. ANOTHER SOURCE OF HYDROGEN PEROXIDE EXPLOSIONS IS FROM SEALING THE MATERIAL IN STRONG CONTAINERS. UNDER SUCH CONDITIONS EVEN GRADUAL DECOMPOSITION OF HYDROGEN PEROXIDE TO WATER + 1/2

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
				OXYGEN CAN CAUSE LARGE PRESSURES TO BUILD UP IN THE CONTAINERS WHICH MAY BURST EXPLOSIVELY. Corrosive liquid. Oxidizing material. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Avoid contact with a combustible material (wood, paper, oil, clothing...). Keep substance damp using water spray. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed.
9.	Acetic Acid CAS # 64-19-7	Chronic respiratory disease due to long term exposure inhalation Skin disease due to skin contact	Process enclosure, Local exhaust, General dilution ventilation, Personal protective equipments	Remove victim from the spillage location into fresh air area. Small spillage control absorb on paper towel. Large spillage – Evacuate area and stop source of ignition. Dilute with water and collect washed out water in tank and neutralize it in safe manner.
10.	Di methyl sulphate (DMS) CAS # 77-78-1	Extremely hazardous in case of skin contact CARCINOGENIC EFFECTS: Classified + (PROVEN) by OSHA. Classified A2	Engineering Controls: Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective	Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift.

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		(Suspected for human.) by ACGIH The substance is toxic to blood, kidneys, lungs, the nervous system, liver, mucous membranes. Repeated or prolonged exposure.	threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location. Personal Protection: Face shield. Full suit. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves. Boots.	Prevent entry into sewers, basements or confined areas; dike if needed. Eliminate all ignition sources. Call for assistance on disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.
11.	Chloroform CAS # 7-66-3	Potential Chronic Health Effects: CARCINOGENIC EFFECTS: Classified + (Proven.) by NIOSH. Classified A3 (Proven for animal.) by ACGIH, 2B (Possible for human.) by IARC. Classified 2 (Some evidence.) by NTP. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. TERATOGENIC	Engineering Controls: Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the workstation location. Personal Protection: Splash goggles. Lab coat. Vapor respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.	Absorb with an inert material and put the spilled material in an appropriate waste disposal. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.
12.	Acetic anhydride CAS#	Chronic respiratory disease due to long term exposure inhalation	Process enclosure, Local exhaust, General dilution ventilation, Personal protective equipments	Remove victim from the spillage location into fresh air area. Small spillage control absorb on paper towel.

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
	108-24-7	Skin disease due to skin contact		Large spillage – Evacuate area and stop source of ignition. Dilute with water and collect washed out water in tank and neutralize it in safe manner.
13.	Acetic Acid CAS# 64-19-7	Chronic respiratory disease due to long term exposure inhalation Skin disease due to skin contact	Process enclosure, Local exhaust, General dilution ventilation, Personal protective equipments	Remove victim from the spillage location into fresh air area. Small spillage control absorb on paper towel. Large spillage – Evacuate area and stop source of ignition. Dilute with water and collect washed out water in tank and neutralize it in safe manner.
14.	Nitric acid CAS# 7697-37-2	The substance may be toxic to lungs, mucous membranes, upper respiratoryp. 2 tract, skin, eyes, teeth. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection.	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.	Corrosive liquid. Oxidizing material. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other noncombustible material. Do not get water inside container. Avoid contact with a combustible material (wood, paper, oil, clothing...). Keeps substance damp using water spray. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Neutralize the residue with a dilute solution of sodium carbonate. Be careful that the product is not present at a concentration level above

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
				TLV.
15.	Hydrochloric Acid	Very hazardous in case of skin contact (corrosive, irritant, permeator), of eye contact (irritant, corrosive), of ingestion, Slightly Hazardous in case of inhalation (lung sensitizer). Non-corrosive for lungs. Liquid or spray mist may produce tissue damage Particularly on mucous membranes of eyes, mouth and respiratory tract. Skin contact may produce burns. Inhalation of the Spray mist may produce severe irritation of respiratory tract, characterized by coughing, choking, or shortness of breath. Severe over-exposure can result in death.	Provide close process and scrubber on process vent and storage vent	Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift.
16.	Toluene CAS # 108-88-3	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
17.	Sulfuric	Prolonged or repeated skin contact	Facilities storing or utilizing this	Clean up spills immediately, observing

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
	Acid	may cause dermatitis. Prolonged or repeated inhalation may cause nosebleeds, nasal congestion, erosion of the teeth, perforation of the nasal septum, chest pain and bronchitis. Prolonged or repeated eye contact may cause conjunctivitis. Effects may be delayed. Workers chronically exposed to sulphuric acid mists may show various lesions of the skin, tracheobronchitis, stomatitis, conjunctivitis, or gastritis. Occupational exposure to strong inorganic acid mists containing sulfuric acid is carcinogenic to humans.	material should be equipped with an eyewash facility and a safety shower. Use adequate general or local exhaust ventilation to keep airborne concentrations below the permissible exposure limits. Use a corrosion-resistant ventilation system.	precautions in the Protective Equipment section. Carefully scoop up and place into appropriate disposal container. Provide ventilation. Do not get water inside containers. Cover with dry earth, dry sand, or other non-combustible material followed with plastic sheet to minimize spreading and contact with water.
18.	Acetonitrile CAS # 75-05-8	Potential Acute Health Effects: skin contact (irritant), of eye contact (irritant), Potential Chronic Health Effects: The substance is toxic to blood, kidneys, lungs, liver, mucous membranes, gastrointestinal tract, upper respiratory tract, skin, eyes, central nervous system	Closed system, ventilation, explosion-proof electrical equipment and lighting. Do NOT use compressed air for filling, discharging, or handling.	Ventilation. Remove all ignition sources. Collect leaking liquid in sealable containers. Absorb remaining liquid in dry sand or inert absorbent and remove to safe place. Do NOT wash away into sewer. Personal protection: complete protective clothing including self-contained breathing apparatus

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		(CNS). The substance may be toxic to the reproductive system.		
19.	Ethyl Alcohol CAS # 64-17-5	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth,sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
20.	Ethyl Acetate CAS # 141-78-6	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
21.	Iodine	Hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation. The substance is toxic to thyroid. The substance may be toxic to blood, kidneys, liver, skin, eyes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure of the eyes to a low level of dust can produce eye irritation. Repeated skin exposure can produce local	Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.	Corrosive solid. Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal. Be

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		skin destruction, or dermatitis. Repeated inhalation of dust can produce varying degree of respiratory irritation or lung damage.		
22.	Methanol CAS# 67-56-1	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous.	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
23.	Methylene Chloride CAS # 75-09-2	CARCINOGENIC EFFECTS: Classified + (Proven.) by OSHA. The substance is toxic to lungs, the nervous system, liver, mucous membranes, central nervous system (CNS).	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the workstation location. Personal Protection:	Absorb with an inert material and put the spilled material in an appropriate waste disposal. Be careful that the product is not present at a concentration level above TLV
24.	N - Heptane	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
25.	N - Propanol	The substance is toxic to blood, the reproductive system, liver, upper respiratory tract, skin, central nervous	Provide close process	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed.
26.	Phosphoric acid (85 %)	Very hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, . Hazardous in case of skin contact (corrosive, permeator), of eye contact (corrosive). Slightly hazardous in case of inhalation (lung sensitizer)	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.	Corrosive liquid. Poisonous liquid. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed.
27.	Pyridine CAS # 110- 86 -1	Target organs: Liver, kidneys, nerves, Bone Marrow. Persons with pre-existing disorders may be more susceptible. This Product has been reported to be a possible carcinogen. Long-term exposure may cause liver, kidney or CNS damage. Typical STEL 10 ppm. Typical PEL 15 ppm.	Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Ventilation fans and other electrical service must be non-sparking and have an explosion-proof design.	Absorb spill with inert material (e.g. vermiculite, sand or earth), then place in suitable container. Clean up spills immediately, observing precautions in the Protective Equipment section. Remove all sources of ignition. Use a spark-proof tool. Provide ventilation. Prevent spreading of vapors through sewers, ventilation systems and confined areas. Evacuate unnecessary personnel. Approach spill from upwind. Use water spray to cool and disperse vapors, protect personnel, and dilute spills to form

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
				nonflammable mixtures. Control runoff and isolate discharged material for proper disposal.
28.	Thionyl Chloride CAS # 771909-7	Corrosive. Extremely destructive to tissues of the mucous membranes and upper respiratory tract. Symptoms may include burning sensation, coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting. Inhalation may be fatal as a result of spasm inflammation and edema of the larynx and bronchi, chemical pneumonitis and pulmonary edema. Prolonged/ repeated exposure may cause conjunctivitis, dermatitis, rhinitis, and pneumonitis.	Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower. Use only under a chemical fume hood.	Do not contact with water. Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Isolate hazard area. Keep unnecessary and unprotected personnel from entering. Contain and recover liquid when possible. Neutralize with alkaline material (soda ash, lime), then absorb with an inert material (e. g., vermiculite, dry sand, earth), and place in a chemical waste container. Do not use combustible materials, such as saw dust. Do not flush to sewer!
29.	Aluminum chloride CAS# 7446-70-0	The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated exposure of the eyes to a low level of dust can produce eye irritation. Repeated skin exposure can produce local skin destruction, or dermatitis. Repeated inhalation of dust can	Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.	Corrosive solid. Poisonous solid. Stop leak if without risk. Do not get water inside container. Do not touch spilled material. Use water spray to reduce vapors. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal.

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
		produce varying degree of respiratory irritation or lung damage. Repeated exposure to a highly toxic material may produce general deterioration of health by an accumulation in one or many human organs.		
30.	Acetyl Chloride CAS# 75-36-5	The substance is toxic to lungs, mucous membranes. Repeated or prolonged exposure to the substance can produce target organs damage. Repeated or prolonged contact with spray mist may produce chronic eye irritation and severe skin irritation. Repeated or prolonged exposure to spray mist may produce respiratory tract irritation leading to frequent attacks of bronchial infection.	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective threshold limit value. Ensure that eyewash stations and safety showers are proximal to the work-station location.	Flammable liquid. Corrosive liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not get water inside container. Do not touch spilled material. Use water spray curtain to divert vapor drift. Prevent entry into sewers, basements or confined areas; dike if needed. Call for assistance on disposal.
31.	n- Butanol CAS # 71-36-3	Repeated or prolonged exposure is not known to aggravate medical condition	Provide exhaust ventilation or other engineering controls to keep the airborne concentrations of vapors below their respective Threshold limit value. Ensure that eyewash stations and safety showers are proximal to the	Flammable liquid. Keep away from heat. Keep away from sources of ignition. Stop leak if without risk. Absorb with DRY earth, sand or other non-combustible material. Do not touch spilled material. Prevent entry into sewers, basements or confined areas; dike if needed. Be careful that the product is not present at a

Sr. No.	Chemical	Occupational health impact on employees	Measures to keep exposure below TLV/ PEL	EMP for STEL & IDLH
			work-station location.	concentration level above TLV
32.	Urea CAS# 57-13-6	The substance may be toxic to blood, cardiovascular system. Repeated or prolonged exposure to the substance can produce target organs damage	Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.	Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

7.10 DO'S AND DON'T'S FOR STRENGTHENING HSE

7.10.1 DO's

- Wash affected part immediately with plenty of water.
- Take the patients affected by toxic vapour to well-ventilated area.
- In case of vapor inhalation/gas poisoning, immediately render first aid to the patient and then move the patient to First Aid Centre.
- In case of emergency everyone should try to reach at Assembly point. Move in direction perpendicular to direction of gas leakage.
- In case of emergency all (except emergency staff) should reach at nearest assembly point.
- In case of vapour inhalation/gas poisoning, immediately render first aid to the patient and then move to First Aid Centre.
- Use ear plug/muff in high noise area.
- Work permit system to be followed before starting any hot work, vessel entry or working at height.
- Barricade and mark hazardous/unsafe area
- Ensure use of safety belt while working at height.
- Electrical cables should be protected from water and from attack by corrosive substances.
- Maintain good housing keeping, it will eliminate many unnecessary hazards.
- Protruding nail should be pulled out or bent over.
- All aisles, passage ways and stairways should be maintained, clean and unobstructed.
- Employees must know the locations of fire extinguisher and fire exists.
- During emergency be calm and do not get panicky.

7.10.2 DON'T's:-

- Smoking or carry cigarettes/bidis, match box, lighter, mobile phone or any instruments etc. in the plant/battery limit area. It is prohibited.
- Unauthorized entry into battery limits of every plant is prohibited.
- Moving in the plant area without wearing safety helmet and safety shoes is not permitted.
- Wearing of loose garments, ornaments etc. in the plant area.
- Cotton waste, paper, oil etc. should not be left in plant area.

- Do not follow shortcuts, use proper roads, pathways, wherever provided.
- Do not wear chappals or slippers in the plant.
- No automobile vehicle should be allowed to enter in the plant area without muffler or exhaust.
- Chewing of tobacco, betel nut, chewing gum and other such items are not allowed in any of process utility area.

7.11 HAZARD IDENTIFICATION

7.11.1 INTRODUCTION

Risk assessment process rests on identification of specific hazards, hazardous areas and areas vulnerable to effects of hazardous situations in facilities involved in processing and storage of chemicals.

In fact the very starting point of any such assessment is a detailed study of materials handled & their physical / chemical / thermodynamic properties within the complex at various stages of manufacturing activity. Such a detailed account of hazardous materials provides valuable database for identifying most hazardous materials, their behaviour under process conditions, and their inventory in process as well as storage and hence helps in identifying vulnerable areas within the complex.

Hazardous posed by particular installation or a particular activity can be broadly classified as fire and explosive hazards and toxicity hazards. Whether a particular activity is fire and explosive hazardous or toxicity hazardous primarily depends on the materials handled and their properties.

7.11.2 Identification of Hazardous Areas:

A study of process as given in chapter 3 of the report indicates the following:

- All Plants and products will batch process plant.
- All hazardous liquid raw materials will charged in reactor by pumping, vacuum, gravity or by nitrogen pressure, etc. Powder raw materials will be charged through hopper in reaction tank.
- No inventory of any chemicals in process area.

Various raw materials used in the manufacturing processes are listed in chapter-2 along with mode/type of storage & storage conditions. It can be readily seen that raw materials even though hazardous in nature, will be used in small quantities & storage quantities will also very low at process plant. Most of hazardous chemicals are stored in dedicated Explosive licence premises. List of chemicals stored in bulk quantities is provided in chapter-2.

Hazardous properties are provided in chapter-2, Occupational health impact to employees and emergency action plan and its antidotes provided in above table.

7.11.3 Failure Frequencies

Hazardous material release scenarios can be broadly divided into 2 categories

I) Catastrophic failures which are of low frequency and

II) Ruptures and leaks which are of relatively high frequency.

Releases from failure of gaskets, seal, rupture in pipelines and vessels fall in the second category whereas catastrophic failure of vessels and full bore rupture of pipelines etc. fall into the first category.

7.11.3.1 TYPICAL FAILURE FREQUENCIES ARE GIVEN BELOW

TABLE 7.10

TYPICAL FAILURE FREQUENCIES ARE GIVEN BELOW

Item	Mode of failure	Failure frequencies
Atmospheric storage	Catastrophic failure Significant leak	10-9 /yr 10-5 /yr
Process Pipelines		
< = 50 mm dia	Full bore rupture Significant leak	8.8 x 10-7 /m.yr 8.8 x 10-6 /m.yr
> 50 mm <=150mm dia	Full bore rupture Significant leak	2.6 x 10-7 /m.yr 5.3 x 10-6 /m.yr
< 150 mm dia	Full bore rupture Significant leak	8.8 x 10-8 /m.yr 2.6 x 10-6 /m.yr
Hoses	Rupture	3.5 x 10-2 /m.yr

TABLE 7.11

Table of Estimated Frequencies of Vapour Cloud Explosions (from Lees, 1996):

(1) Caused by failure of:	Frequency	Units
Pressure vessel	1E-5	occ/plant.yr
Special pipeline	1E-5 to 1E-4	occ/plant.yr
Normal pipeline	1E-4 to 1E-3	occ/plant.yr
Pump; normal duty	1E-2	occ/plant.yr
Pump; severe duty pump	1E-1	occ/plant.yr
Reciprocating Compressor	1E-1	occ/plant.yr
(2) Caused by leak from:		
Batch reactor	1E-2 to 1E-1	occ/plant.yr
Tanker filling hose	1E-2 to 1E-1	occ/plant.yr

TABLE 7.12

TABLE OF FAILOURE RATES FOR PRESSURE STORAGE

Table of Failure Rates For Pressure Storage:

Event	Frequency or Probability
Catastrophic failure of vessel: • Complete failure • Failure equivalent to 6in nozzle	3E-6 occ/vessel.yr 7E-6 occ/vessel.yr
Fracture in liquid line: • Pipework • Fittings	3E-7 occ/m.yr 5E-6 occ/item.yr
Release due to overfilling	1E-4 occ/vessel.yr
Fracture of vapour line	3E-6 occ/m.yr
Serious leak (1kg/s): • 6in pipework • 3in pipework • Flange • Pump seal	6E-6 occ/m.yr 6E-5 occ/m.yr 3E-4 occ/m.yr 5E-3 occ/m.yr
Release in course of draining or sampling (1.5kg/s) • Release per operation • Draining operations • Sampling operations • Failure to recover during draining • Failure to recover during sampling	1E-4 (release/operation) 50 occ/yr 100 occ/yr P=1E-1 P=1E-2

7.11.4 EVALUATION OF PROCESS AREAS

- All raw material and finished product will be stored finished product raw material in tank farm area and drum storage area and required material will be charged in process through pump and in close circuit.
- Maximum Seven days running products raw material inventory will be kept in drum storage area.
- List of chemicals stored in larger quantities is provided in above table, hazardous properties are provided in above table and Occupational health impact to employees and emergency action plan and its antidotes provided in above table.

Considering this, the risk analysis and consequences studies are concentrated on below area.

- (a) PESO Road Tanker Unloading point
- (b) Solvent Tank Farm storage Area
- (c) Hydrogen Cylinder Storage Area
- (d) Bromine storage area
- (e) Warehouse storage area

7.12 RISK ASSESSMENT

7.12.1 Effects of Releases of Hazardous Substances

Hazardous substances may be released as a result of failures / catastrophes, causing possible damage to the surrounding area. In the following discussion, an account is taken of various effects of release of hazardous substances and the parameters to be determined for quantification of such damages.

In case of release of hazardous substances the damages will depend largely on source strength. The strength of the source means the volume of the substance released. The release may be instantaneous or semi-continuous. In the case of instantaneous release, the strength of the source is given in kg and in semi-continuous release the strength of the source depends on the outflow time (kg/s.).

In order to fire the source strength, it is first necessary to determine the state of a substance in a vessel. The physical properties, viz. Pressure and temperature of the substance determine the phase of release. This may be gas, gas condensed to liquid and liquid in equilibrium with its vapour or solids.

Instantaneous release will occur, for example, if a storage tank fails. Depending on the storage conditions the following situations may occur.

The source strength is equal to the contents of the capacity of the storage system.

In the event of the instantaneous release of a liquid a pool of liquid will form. The evaporation can be calculated on the basis of this pool.

7.13 FIRE

7.13.1 JET FIRE

Jet fire causes damage due to the resulting heat radiation. The working level heat radiation impact will vary widely depending on the angle of the flame to the horizontal plane, which mainly depends on the location of the leak. The flame direction was considered horizontal for consequence analysis of leaks and ruptures from process equipment. Jet fire heat radiation impacts were estimated for the identified credible and worst case scenarios.

Upon accidental leakage, the pressurized fluid will disperse as a jet, initially moving forward in the spatial direction of the leak till the kinetic energy is lost and gravity slumping or lifting of the cloud occurs, dependent upon whether the fluid is heavier or lighter than air.

7.13.2 TANK ON FIRE/POOL FIRE

In the event of the instantaneous release of a liquid a pool of liquid will form. The evaporation can be calculated on the basis of this pool.

The heat load on object outside a burning pool of liquid can be calculated with the heat radiation model. This model uses average radiation intensity, which is dependent on the liquid. Account is also taken of the diameter-to-height ratio of the fire, which depends on the burning liquid. In addition, the heat load is also influenced by the following factors:

- Distance from the fire
- The relative humidity of the air (water vapour has a relatively high heat-absorbing capacity)
- The orientation i.e. horizontal/vertical of the objective irradiated with respect to the fire.

7.13.3 FLASH FIRE

The vapour / gas release from a pool would disperse under the influence of the prevailing wind; with material concentration in air reducing with distance. At a particular location downwind, the concentration will drop below its lower flammable level (LFL) value. If ignited within the flammable envelope, the mass of the material available between the LFL and $\frac{1}{2}$ LFL will be likely to burn as a flash fire; rapidly spreading through the cloud from the point of ignition back to the source of release.

Although flash fires are generally low intensity transitory events, the burning velocity is quite high and escape following ignition is not possible. Flash fires often remain close to the ground, where most ignition sources are present. It is assumed that personnel caught inside a flash fire will not survive while those outside suffer no significant harm. If other combustible material is present within the flash fire it is also likely to ignite and a secondary fire could result.

7.14 EXPLOSION

7.14.1 LATE EXPLOSION (UVCE)

The magnitude of the vapour cloud explosion is dependent on the size of the gas cloud that has formed and the degree of congestion in the area, as these determine the acceleration of the flame front.

The TNO GAMES model is used for modeling of vapour cloud explosions, as the model incorporates the characteristics of the explosion, such as the type of fuel, its reactivity, the effect of obstacles in the congested region, etc. Turbulence is the governing factor in blast generation, which could intensify combustion to the level that will result in an explosion. Obstacles in the path of vapour cloud or when the cloud finds a confined area, as under the bullets, often create turbulence. Insignificant level of confinement will result in a flash fire. The VCE will result in overpressures.

It may be noted that VCEs have been responsible for very serious accidents involving severe property damage and loss of lives. Vapour Cloud Explosions in the open area with respect to Pure Methane is virtually impossible due to their lower density.

7.14.2 BALL FIRE / BLEVE

This happens during the burning of liquid, the bulk of which is initially over rich (i.e. above the upper flammable limit.). The whole cloud appears to be on fire as combustion is taking place at eddy boundaries where air is entrained (i.e. a propagating diffusion flame). The buoyancy of the hot combustion products may lift the cloud from the ground, subsequently forming a mushroom shaped cloud. Combustion rates are high and the hazard is primarily thermal.

7.15 MODES OF FAILURE

- Liquid release due to catastrophic failure of storage vessel or road tanker.
- Liquid release through a hole/crack developed at welded joints/flanges / nozzles / valves etc.
- Vapour release due to exposure of liquid to atmosphere in the above scenarios.
- Gas release due to catastrophic failure of Ammonia cylinder or outlet valve/line failure.

TABLE: 7.13

MODES OF FAILURE

Event		Causes
Tank on Fire/	-	Catastrophic failure of tank + Ignition availability
Pool fire	-	Failure of liquid outlet line + Ignition availability
Fire Ball/BLEVE	-	Catastrophic failure of road tanker/ storage tank
Flash Fire	-	Vapour generation due to substrate and wind
UVCE Vapour cloud generation and about 15 % of total vapour mass Above the UEL-LEL % Ignition availability		

Toxic gas dispersion - Toxic Gas release due to catastrophic failure of tonner/bullet/
Tanks and ignition not available within LEL- UEL range.

Considering the quantity of storages & nature of Toxic nature and Flammable storage, following scenarios were taken up for detailed analysis & safe distances computed:

Failure cases considered for consequence analysis are representative of worst-case scenarios. Probability of occurrence of such cases is negligible (less than 1×10^{-6} per year) because of strict adherence to preventive maintenance procedures within the complex.

General probabilities for various failure is provided in Table-7.10, 7.11 and 7.12, but consequences of such cases can be grave & far reaching in case such systems fail during life history of the company. Hence such scenarios are considered for detailed analysis. It is to be noted however that such situations are not foreseeable or credible as long as sufficient measures are taken. Also, consequence analysis studies help us evaluate emergency planning measures of the Company.

7.16 IMPACT CRITERIA

Consequence assessment is conducted to understand the impact of identified scenarios in terms of Thermal radiation (Jet fire, Flash Fire), Explosion (vapor cloud explosion- UVCE). A range of potential consequences are assessed for each of the release scenarios identified. This step identifies the fatality probability, based on hazard type and caused by each release case, to personnel at a range of distances.

Estimate of damage or impact caused due to thermal radiation, explosion overpressure and toxic effects is generally based on the published literature on the subject. The actual potential consequences from these likely impacts can then be visualized by superimposing the damage effect zones on the proposed layouts and identifying the elements within the project which might be adversely affected, should one or more hazards materialize in practice. The damage criteria used in the present study is described in the following sections.

7.17 DAMAGE CRITERIA FOR HEAT RADIATION

Damage effects vary with different scenarios. Calculations for various scenarios are made for the above failure cases to quantify the resulting damages.

The results are translated in term of injuries and damages to exposed personnel, equipment, building etc.

Tank on fire /Pool fire due to direct ignition source on tank or road tanker or catastrophic failure or leakage or damage from pipeline of storage facilities or road tanker unloading arm, can result in heat radiation causing burns to people depending on thermal load and period of exposure.

All such damages have to be specified criteria for each such resultant effect, to relate the quantifier damages in this manner, damage criteria are used for Heat Radiation.

TABLE 7.14

PRACTICAL SIGNIFICANCE OF RADIATION INTENSITY

Heat Radiation (kW/m²)	Damage to Equipment	Damage to People
1.2	Solar Heat at Noon	
1.6	---	Minimum Level of pain threshold
2.0	PVC insulated cables damaged	---
4.0	---	Causes pain if duration is longer than 20 seconds. Blistering is unlikely.
4.5	---	Blistering of skin
6.0	---	First degree burn
9.5	---	Pain threshold reached after 8 seconds. Second degree burns after 20 seconds.
12.0	---	Initiation of secondary fires
12.5	Minimum energy to ignite wood with a flame; Melts plastic tubing.	First degree burns in ten seconds. 1% Fatality in 20 sec, 30% Fatality in 30 seconds.
16.0	---	Severe burns after 5 seconds.
21.2	---	1% Fatality in 10 seconds, with protection of clothing
25.0	Minimum energy to ignite wood at indefinitely long exposure without a flame.	100 % Fatality in 1 (one) minute.
27	--	Third degree burns (30secs)
30.0	Damage to plant & machinery	--
37.5	Severe damage to plant	100 % Fatality

7.18 EXPLOSION / OVER PRESSURE

In case of vapour cloud explosion, two physical effects may occur:

A flash fire over the whole length of the explosive gas cloud;

A blast wave, with typical peak overpressures circular around ignition source.

TABLE 7.15

PRACTICAL SIGNIFICANCE OF OVERPRESSURE

Overpressure (bar)	Mechanical Damage to Equipment	Damage to People
0.2068	Heavy damage to plant & structure	Fatality probability = 1 for humans indoor as well as outdoor > 50% eardrum damage > 50% serious wounds from flying objects
0.1379	Repairable damage to building and house	1% death> 1% eardrum damage > 1% serious wounds from flying objects
0.02068	10% glass damage, Safe distance	---

7.19 CONSEQUENCE ANALYSIS

7.19.1 CONSEQUENCE ANALYSIS

In the risk analysis study, probable damages due to worst case scenarios were quantified and consequences were analyzed with object of emergency planning. Various measures taken by the company and findings of the study were considered for deciding acceptability of risks.

7.19.2 THE CATASTROPHIC/ RUPTURE FAILURE AND MAXIMUM CREDIBLE LOSS SCENARIOS (MCLS)

TABLE: 7.16-A

IDENTIFIED FOR PLANT BASE ON ABOVE CRITERIA IS LISTED BELOW

Sec No.		Scenario Description	Storage Condition (A/G or U/G)	Material	Equipments	Capacity KL / MT	Operating Pressure Kg/cm ² & temperature ⁰ C										
1	Acetone 20 KL Road Tanker Unloading point Catastrophic failure		A/G	Acetone	Road Tanker	20 KL	ATP										
	1.1	Pool Fire															
	1.2	Flash Fire															
	1.3	Late Explosion Worth case															
2	Acetone 20 KL Road Tanker Unloading point 25 mm Leak							A/G	Acetone	Road Tanker	20 KL	ATP					
	2.1	Pool Fire															
	2.2	Jet Fire															
	2.3	Flash Fire															
	2.4	Late Explosion Worth case															
3	Acetone 20 KL Road Tanker Unloading point 50 mm Hose Failure												A/G	Acetone	Road Tanker	20 KL	ATP
	3.1	Pool Fire															
	3.2	Jet Fire															
	3.3	Flash Fire															
	3.4	Late Explosion Worth case															

Sec No.		Scenario Description		Storage Condition (A/G or U/G)	Material	Equipments	Capacity KL / MT	Operating Pressure Kg/cm ² & temperature ⁰ C										
4	Methanol 20 KL Road Tanker Unloading point Catastrophic failure			A/G	Methanol	Road Tanker	20 KL	ATP										
	4.1	Pool Fire																
	4.2	Flash Fire																
	4.3	Late Explosion Worth case																
5	Methanol 20 KL Road Tanker Unloading point 25 mm Leak								A/G	Methanol	Road Tanker	20 KL	ATP					
	5.1	Pool Fire																
	5.2	Jet Fire																
6	Methanol 20 KL Road Tanker Unloading point 50 mm Hose Failure													A/G	Methanol	Road Tanker	20 KL	ATP
	6.1	Pool Fire																
	6.2	Jet Fire																
	6.3	Flash Fire																
	6.4	Late Explosion Worth case																
7	Toluene 20 KL Road Tanker Unloading point Catastrophic failure			A/G	Toluene	Road Tanker	20 KL	ATP										
	7.1	Pool Fire																
	7.2	Flash Fire																
	7.3	Late Explosion Worth case																
8	Toluene 20 KL Road Tanker Unloading point 25 mm Leak								A/G	Toluene	Road Tanker	20 KL	ATP					
	8.1	Pool Fire																
	8.2	Jet Fire																
9	Toluene 20 KL Road Tanker Unloading point 50 mm Hose Failure													A/G	Toluene	Road Tanker	20 KL	ATP
	9.1	Pool Fire																
	9.2	Jet Fire																

Sec No.	Scenario Description	Storage Condition (A/G or U/G)	Material	Equipments	Capacity KL / MT	Operating Pressure Kg/cm ² & temperature °C
	9.3	Flash Fire				
	9.4	Late Explosion Worth case				
10	Ethanol 20 KL Storage Tank Catastrophic failure		A/G	Ethanol	Storage Tank	20 KL
	10.1	Pool Fire				
	10.2	Flash Fire				
	10.3	Late Explosion Worth case				
11	Ethanol 20 KL Storage Tank 50 mm Leak		A/G	Ethanol	Storage Tank	ATP
	11.1	Pool Fire				
	11.2	Jet Fire				
	11.3	Flash Fire				
12	Hydrogen 7 M ³ Cylinder Rupture Catastrophic failure		A/G	Hydrogen	Cylinder	7 M ³
	12.1	Fire ball / BLEVE				
	12.2	Flash Fire				
	12.3	Late Explosion Worth case				
13	Hydrogen 7 M ³ Cylinder Rupture 10 mm Leak		A/G	Hydrogen	Cylinder	200 Kg/cm ²
	13.1	Jet Fire				
	13.2	Flash Fire				
	13.3	Late Explosion Worth case				
14	Bromine Pack of six 3 Kg glass bottle in wooden case		A/G	Bromine	Glass Bottle	18 Kg
	14.1	Maximum Concentration footprint				
15	Ware House Fire		A/G	Warehouse Storage	Drum Storage	80 KL
	15.1	Drum Storage - Pool Fire				
	15.2	Drum Storage – BLEVE				

7.19.3 CONSEQUENCE RESULTS

TABLE: 7.16-B

CONSEQUENCE RESULTS

Sc e. No	Scenario	Failure Case	Latitude	Longitude	Jet Fire Radiation Intensity (Kw / M2)			Pool Fire Radiation Intensity (Kw / M2)			Flash Fire ppm		Late Explosion Worth Case (Bar)		
					37.5	12.5	4.0	37.5	12.5	4.0	LFL	½ UFL	0.206	0.137	0.020
											26000 ppm	13000 ppm	8	9	68
1	Acetone 20 KL Road Tanker	Catastrophic Rupture	22°34'29.36"N	73°26'48.71"E	-	-	-	62.49	110.70	178.5	41.62	59.48	66.73	72.71	176.4
2	Unloading point	25 mm Leak			NR	15.13	18.96	8.07	15.90	24.28	18.15	33.13	37.78	40.44	83.83
3		50 mm Hose Failure			NR	17.56	22.29	9.88	21.42	34.38	33.08	53.53	67.94	73.93	173.2
4	Methanol 20 KL Road Tanker	Catastrophic Rupture	22°34'29.36"N	73°26'48.71"E	-	-	-	37.06	59.44	92.20	73000 ppm	36500 ppm	17.93	20.58	64.42
5	Unloading point	25 mm Leak			NR	NR	13.72	NR	14.12	21.57	-	-	-	-	-
6		50 mm Hose Failure			NR	NR	14.78	NR	18.53	29.53	2.43	15.67	13.24	14.31	32.28
7	Toluene 20 KL Road Tanker	Catastrophic Rupture	22°34'29.36"N	73°26'48.71"E	-	-	-	NR	37.33	86.34	12000 ppm	6000 ppm	26.77	29.02	73.75
8	Unloading point	25 mm Leak			NR	5.02	7.52	8.10	16.24	25.38	-	-	-	-	-
9		50 mm Hose Failure			NR	7.02	10.31	7.27	17.41	30.59	2.93	15.13	12.28	13.08	25.87

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Sc e.	Scenario	Failure Case	Latitud e	Longit ude	Jet Fire Radiation Intensity (Kw / M2)			Pool Fire Radiation Intensity (Kw / M2)			Flash Fire ppm		Late Explosion Worth Case (Bar)		
10	Ethanol 20 KL Storage Tank	Catastrophic Rupture	22°34'28.43"N	73°26'47.45"E	-	-	-	45.60	82.75	130.0	43000 ppm	21500 ppm	17.41	19.88	60.86
11		50 mm Leak			NR	15.40	17.62	14.19	27.40	41.83	NR	5.41			
12	Hydrogen 7 M3 Cylinder Rupture	Catastrophic Rupture	22°34'28.95"N	73°26'48.14"E	-	-	-	Fire ball Radiation Intensity (Kw / M2)			40000 ppm	20000 ppm	50.35	60.97	272.9
								37.5	12.5	4.0					
13		10 mm Leak						12.55	14.78	17.42	-	-			
14	Bromine Pack of six 3 Kg glass bottle in wooden case	Maximum Concentration footprint	22°34'28.21"N	73°26'47.87"E	Maximum concentration footprint										
					1075 ppm	3 ppm	0.1 ppm								
					NR	37.50	70.36								
15	Ware House Fire	Pool Fire	22°34'28.21"N	73°26'47.88"E	Fire ball Radiation Intensity (Kw / M2)			Pool Fire Radiation Intensity (Kw / M2)							
					37.5	12.5	4.0	37.5	12.5	4.0					
					26.0	46.0	80.0	26.4	45.0	79.5					

7.20 CONCLUSION

FLASH FIRE CASES

Flash Fire is usually dispersion case, where the extent of cloud until the flammability limits (LEL, UEL) is measured. The important factor in measuring the extent of cloud is atmospheric stability & wind speed. As the wind speed increases, the cloud tends to move further down & gets diluted which results in lower quantity of material in the flammability limits i.e. lower strength of flash fire. The highest damage distances for flash fire are for isolatable is Scenario 1 Acetone 20 KL Road Tanker Unloading point Rupture at 1.5F weather condition. The maximum damage distance for Flash Fire is **41.62 meter** (26000 ppm) & **59.48 meter (13000 ppm)** – 1.5F of whether condition. UFL is defined as burning zone, which means people caught within the burning zone are exposed to a fatality rate of 100%.

JET FIRE

As can be seen from the results of the summary of the Quantitative Risk Analysis study, the Fatality distance due to Scenario 3 Acetone 20 KL Road Tanker Unloading point 50 mm Hose Failure at dispersion of **NR** at 37.5Kw/M², **17.56 meter** at 12.5 Kw/M² and **22.29 Meter** at 4.0 Kw/M².

POOL FIRE

As can be seen from the results of the summary of the Quantitative Risk Analysis study, the Fatality distance due to Scenario 1 Acetone 20 KL Road Tanker Unloading point Rupture at dispersion of **62.49 meter** at 37.5Kw/M², **110.7 meter** at 12.5 Kw/M² and **178.5 Meter** at 4.0 Kw/M².

FIREBALL – BLEVE

As can be seen from the results of the summary of the Quantitative Risk Analysis study, the Fatality distance due to Scenario 12 Hydrogen 7 M³ Cylinder Rupture dispersion of **36.74 meter** at 37.5Kw/M², **64.73 meter** at 12.5 Kw/M² and **112.6 Meter** at 4.0 Kw/M².

LATE EXPLOSION WORTH CASE - UVCE

As can be seen from the results of the summary of the Quantitative Risk Analysis study, the Fatality distance due to Scenario 1 Acetone 20 KL Road Tanker Unloading point Rupture dispersion of **66.73 meter** at 0.2068 bar, **72.71 meter** at 0.1379 bar and **176.4 meter** at 0.02068 bar.

MAXIMUM CONCENTRATION FOOTPRINT

As can be seen from the results of the summary of the Quantitative Risk Analysis study, the Fatality distance due to Scenario 14 Bromine Pack of six 3 Kg glass bottle in wooden case toxic

release dispersion of NR meter at **1075 ppm** at LC -50 distance, **37.50 meter at 3 ppm** at IDLH distance and **70.36 meter at 0.1 ppm** at TLV distance.

7.21 RISK REDUCTION MEASURES

7.21.1 RECOMMENDATIONS

From the Risk Analysis studies conducted, it would be observed that by and large, the risks are confined within the factory boundary walls in case of fire, explosion and spillage of chemicals. On site emergency plan & preparedness plan to be prepared and implemented to combat such situations. To minimize the consequential effects of the risk scenarios, following steps are recommended.

- Plant should meet provisions of the Manufacture, storage & Import of Hazardous Chemicals Rules, 1986 & the factories Act, 1948.
- Process hazard analysis and HAZOP study to be conducted for each process and recommendation to be implemented.
- Safety measures shall be implemented as per provided in report.
- Explosive licence and other statutory norms shall be incorporated in plant construction.
- Process parameter and safety shall be considered as a built in safe system.
- All new employees shall be trained for safe operation, handling and storage of hazardous process and material.
- Emergency plan shall be prepared as per QRA hazardous scenarios and periodic On Site Emergency, Mock Drills should be conducted, in order to train the staff and make them mentally prepare to tackle emergency.
- Emergency handling facilities should be maintained in a tip top condition round the clock.
- The details of emergency equipments are given in on site emergency Plan along with its quantity shall be procure and maintained.
- Safety devices and control instruments should be calibrated once in a year.
- HSE management system shall be prepared and implemented at early stage of the plant commissioning.
- Permit to work system shall be implemented on 100 % basis for hazardous work to be carried out in the plant.
- Induction safety course should be prepared and training of all new employees before starting duties in plant should be made compulsory.
- Fire hydrant system and sprinkler system needs to be provided.
- Manual call point and smoke detectors to be installed at design level.

- Safety organizational setup to be plan at construction level and HSE department staff to be employed for system setup for proposed facilities.
- Double Static earthing and electrical earthing needs to be provided to all equipments of the plant and earth pit testing to be carried out once in a six months.
- Safe operating procedure to be prepared for hazardous process and material handling process.

7.21.2 CONSEQUENCE CONTUORS

FIGURE7.3

ACETONE 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC RUPTURE – POOL FIRE

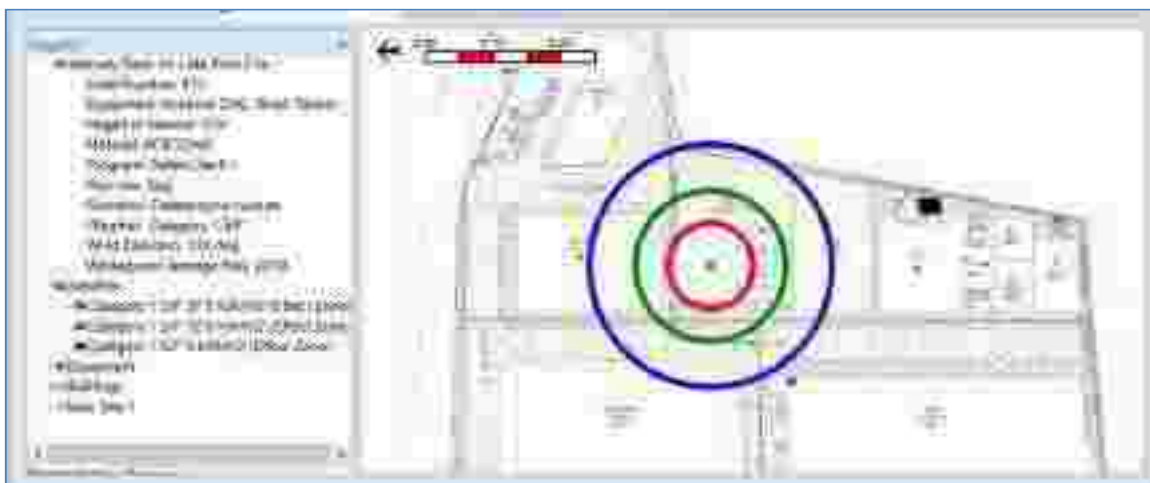


FIGURE7.4

ACETONE 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC RUPTURE – FLASH FIRE



FIGURE 7.5

ACETONE 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC RUPTURE – LATE EXPLOSION WORTH CASE



FIGURE 7.6

ACETONE 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – POOL FIRE



FIGURE 7.7

ACETONE 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – JET FIRE



FIGURE7.8

ACETONE 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – FLASH FIRE



FIGURE7.9

ACETONE 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – LATE EXPLOSION WORTH CASE



FIGURE 7.10

ACETONE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE – POOL FIRE



FIGURE7.11

**ACETONE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE –
JET FIRE**

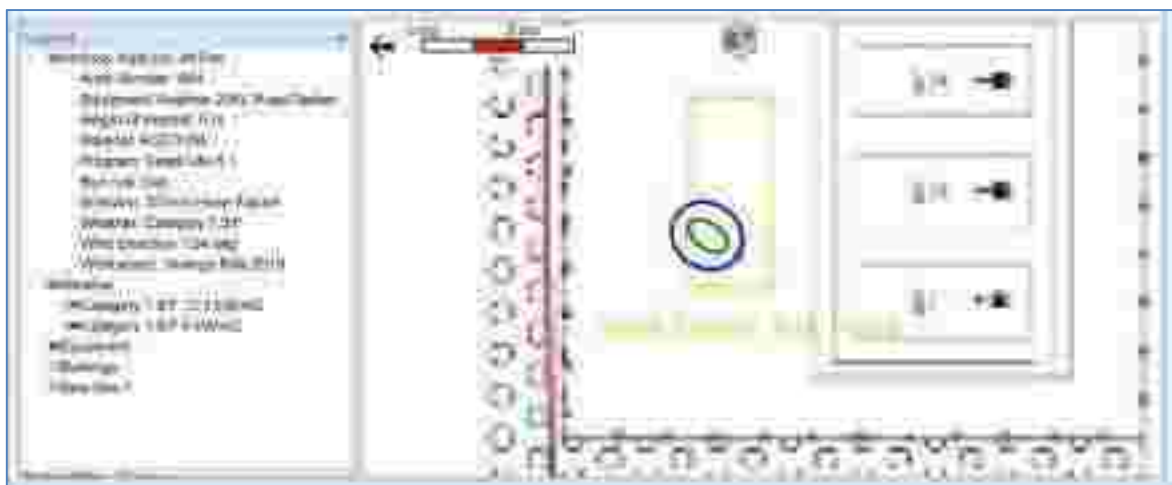


FIGURE7.12

**ACETONE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE –
FLASH FIRE**

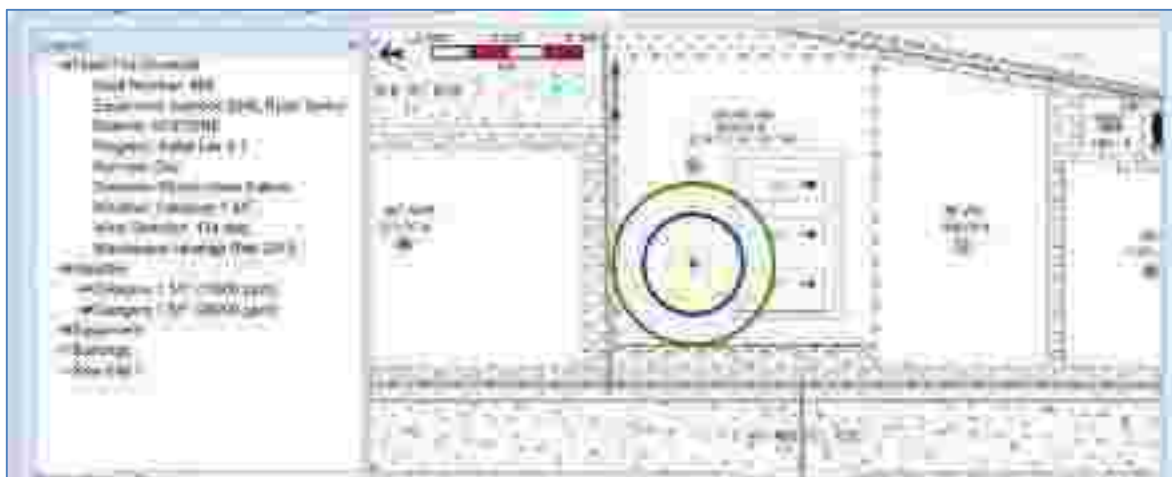


FIGURE 7.13

ACETONE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE – LATE EXPLOSION WORTH CASE



FIGURE 7.14

METHANOL 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC FAILURE – POOL FIRE



FIGURE 7.15

METHANOL 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC FAILURE – FLASH FIRE

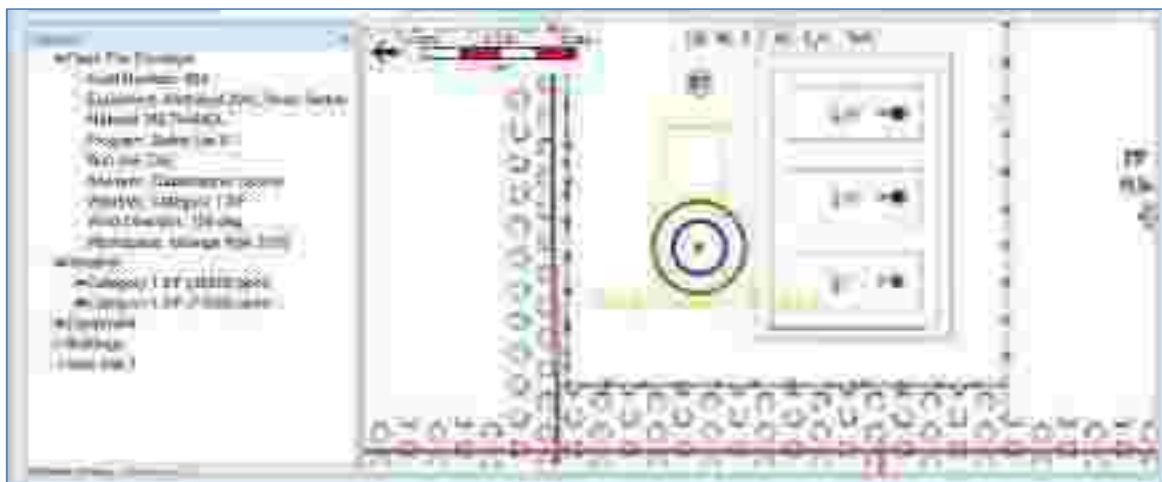


FIGURE 7.16

METHANOL 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC FAILURE – LATE EXPLOSION WORTH CASE

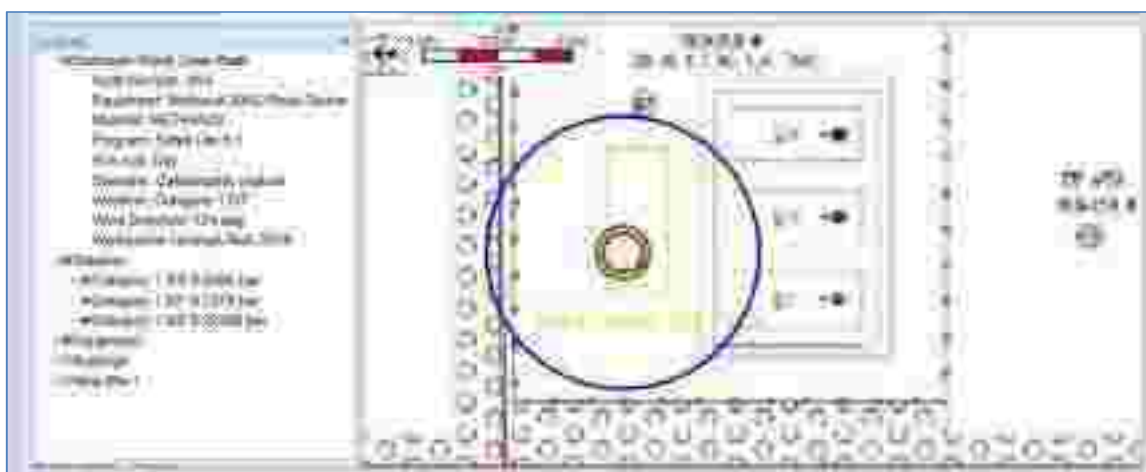


FIGURE 7.17

METHANOL 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – POOL FIRE



FIGURE 7.18

METHANOL 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – JET FIRE



FIGURE7.19

**METHANOL 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE –
POOL FIRE**



FIGURE7.20

**METHANOL20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE –
JET FIRE**



FIGURE7.21

**METHANOL 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE –
FLASH FIRE**



FIGURE7.22

**METHANOL 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE –
LATE EXPLOSION WORTH CASE**



FIGURE7.23

**TOLUENE 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC FAILURE
– POOL FIRE**



FIGURE7.24

**TOLUENE 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC FAILURE
– FLASH FIRE**



FIGURE7.25

**TOLUENE 20 KL ROAD TANKER UNLOADING POINT CATASTROPHIC FAILURE
– LATE EXPLOSION WORTH CASE**



FIGURE7.26

TOLUENE 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – POOL FIRE



FIGURE7.27

TOLUENE 20 KL ROAD TANKER UNLOADING POINT 25 MM LEAK – JET FIRE

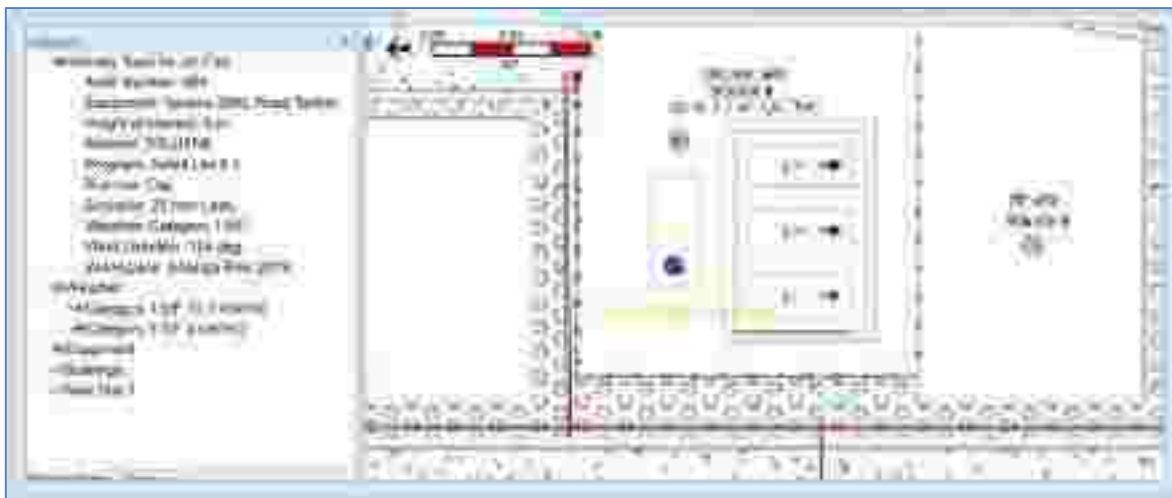


FIGURE7.28

TOLUENE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE – POOL FIRE



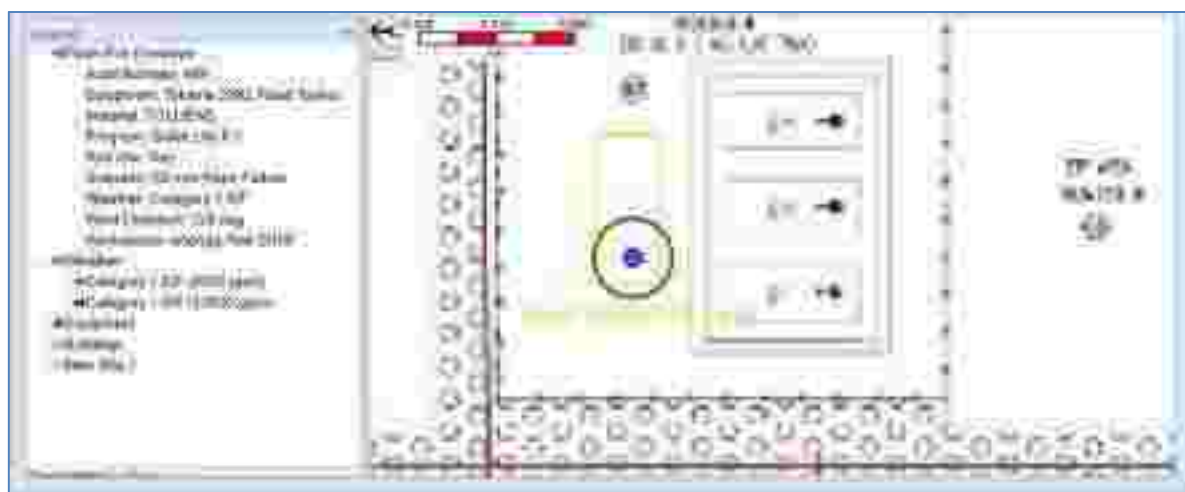
FIGURE7.29

TOLUENE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE – JET FIRE



FIGURE7.30

TOLUENE 20 KL ROAD TANKER UNLOADING POINT 50 MM HOSE FAILURE – FLASH FIRE



ETHANOL 20 KL STORAGE TANK CATASTROPHIC FAILURE – POOL FIRE



FIGURE7.33

ETHANOL 20 KL STORAGE TANK CATASTROPHIC FAILURE – FLASH FIRE



FIGURE7.34

ETHANOL 20 KL STORAGE TANK CATASTROPHIC FAILURE – LATE EXPLOSION WORTH CASE



FIGURE 7.35

ETHANOL 20 KL STORAGE TANK 50 MM LEAK – POOL FIRE

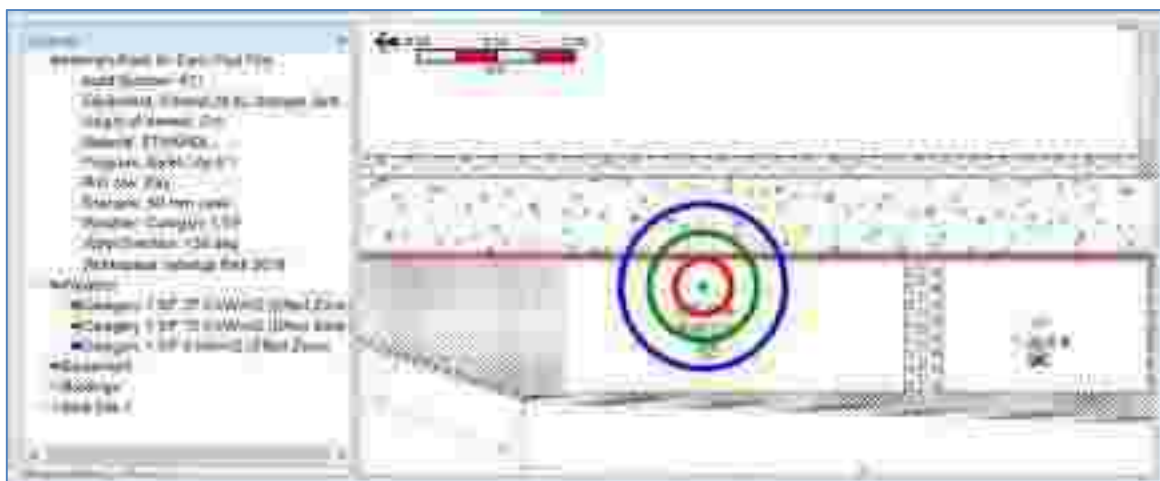


FIGURE 7.36

ETHANOL 20 KL STORAGE TANK 50 MM LEAK – JET FIRE

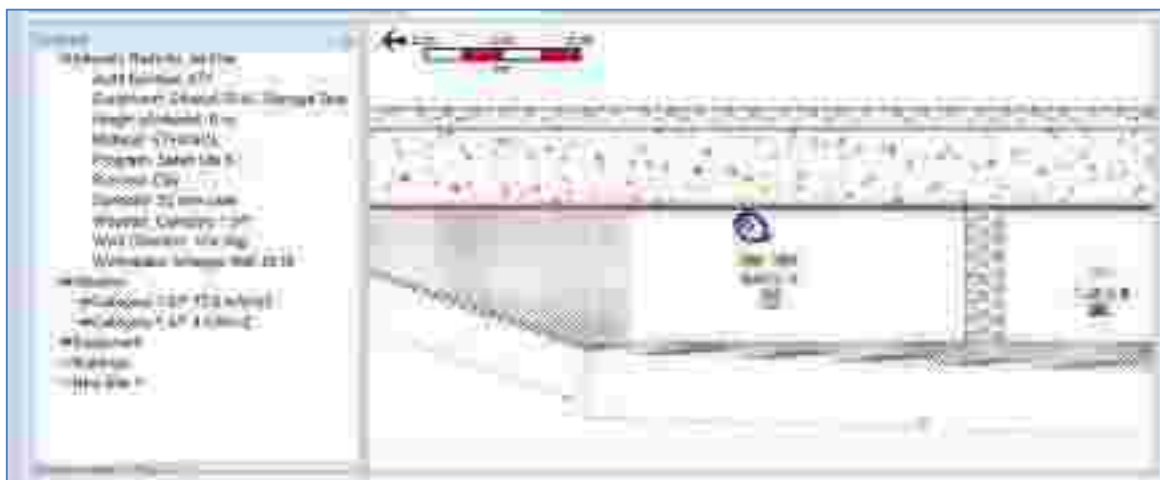


FIGURE7.43

HYDROGEN 7 M3 CYLINDER RUPTURE 10 MM LEAK – LATE EXPLOSION WORTH CASE



FIGURE7.44

BROMINE PACK OF SIX 3 KG GLASS BOTTLE IN WOODEN CASE – MAXIMUM CONCENTRATION FOOTPRINT



FIGURE7.45

DRUM 80 KL STORAGE CATASTROPHIC RUPTURE – FIRE BALL / BLEVE



FIGURE7.46

DDRUM 80 KL STORAGE CATASTROPHIC RUPTURE – POOL FIRE



7.22 SCENARIO BASED ON SITE AND OFF SITE EMERGENCY PLAN

7.22.1 POSSIBLE EMERGENCY: -

TABLE: 7.17

HEAVY SPILLAGE OF SOLVENT FROM ROAD TANKER

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Solvent Unloading point	Heavy spillage of product from the road tanker unloading hose	(1) Hydrocarbon vapour generated and run in down wind direction. (2) Fire and explosion.	(1) Connecting hose disconnected from the flange and 100 % release of material from valve. (2) Rupture of unloading hose. (3) Leaking from flange gasket (4) fire in spill collection drum.	Raised alarm immediately for warning the people if large spillage observed. Do not enter in spillage area. Stop all hot work in this area. Call fire and Safety department Close valve immediately if it is safe to do. Cordon the area immediately. Do not touch any electrical switches in spillage area. Stop all activities in tank farm	First observer/ driver/ cleaner/ operator All employees Operator Operator Operator Driver cleaner All team members	Tanker unloading procedure to be prepared and implemented strictly. Sampling method to be prepared and implemented. Wheel stopper to be provided. Static earthing with interlocking shall be provided. Leakage proof connection hose to be done before starting the

				area. Evacuate non essential persons from the affected area immediately. Evacuate the surrounding area up to 200 meter in all direction. Try to control situation at department level with available resources with full PPEs. Identify the spillage material and refer MSDS for control plan. Inform the Site main Controller (SMC) in detail. Take decision to Declare onsite emergency. Efforts to be made to prevent spreading of Benzene to a large area by containing it in a small area by temporary arrangements or by diverting the spreading oil to a low lying	IC Rescue team Rescue team IC IC IC SMC Fire and spill control team	unloading. No spillage of Benzene to be allowed in tank farm area. All fire fighting equipments to be kept in good working condition. 200 Lit AFFF foam drum to be kept ready in tank farm area for fire fighting. All employees in area to be trained for fire fighting and such scenarios base emergencies. Strict supervision of whole activity responsibility to be define. LEL % base gas detection system to be provided and to be
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				area away from strategic plant areas. Start to spread AFFF foam on spilled material to control evaporation rate. Do not drain spilled material in any trench or sump. Ensure search and rescue and casualties receive attention. Administer first aid to the victim. Make arrangement to send injured person/s to Hospital. If off site emergency situation occur –Inform to following agencies Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office	Fire team Fire team Rescue team First Aid team First Aid team SMC	maintained in good working condition. Emergency telephone number list to be displayed in this area. Incase of emergency – action plan and communication chart to be displayed in this area. Remaining benzene collection crude method of road tanker run forward and backward practices to be stopped immediately. Such crude method will lead road tanker disaster.
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TABLE: 7.18

UNCONFINED POOL FIRE DUE TO HEAVY SPILLAGE FROM ROAD TANKER UNLOADING HOSE

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Benzene Unloading point	Heavy spillage of product from the road tanker unloading hose and it got fire. (Unconfined pool fire)	(1) Unconfined Pool fire (2) In case of Benzene if the liquid does not catch fire, Benzene can evaporate and if the vapor cloud in its movement in the direction of wind, meets any source of ignition, it may result in a vapor cloud explosion.	Immediate ignition available.	Raise fire siren or shouting Fire...Fire....Fire... Evacuate the area immediately. Inform the area incharge. Inform IC in detail. Affected area to be cordoned off. Call fire department immediately and help them for fire fighting. Try to control situation at department level with available resources with full PPEs. If it is found uncontrollable condition by department level inform SMC for onsite	First Observer All employees in this area First observer Department employee Security team IC Department fire fighting team. IC	Tanker unloading procedure to be prepared and implemented strictly. Sampling method to be prepared and implemented. Wheel stopper to be provided. Static earthing with interlocking shall be provided. Leakage proof connection hose to be done before starting the unloading. No spillage of Benzene to be allowed in tank farm area.

				emergency situation.	SMC	All fire fighting equipments to be kept in good working condition.
				Declare on site emergency if required.	Fire team	
				Start fire hydrant system or water hose rill and spray water on nearby tank farm area for cooling purpose.	Fire team	200 Lit AFFF foam drum to be kept ready in tank farm area for fire fighting.
				Use foam fire extinguishers for firefighting of solvent fire.	All team member	All employees in area to be trained for fire fighting and such scenarios base emergencies.
				Do not enter in fire prone area.	SMC	
				If the fire is not controlled, Emergency may be declared and on site emergency plan to be brought into action and services from outside agencies to be requisitioned, if considered necessary.	SMC and all dept. head.	Strict supervision of whole activity responsibility to be define.
				If fire found uncontrollable condition call fire brigade and mutual aider for help.	SMC	LEL % base gas detection system to be provided and to be maintained in good working condition.
				All hazardous activates stop at site.	Rescue team	Emergency telephone number list to be displayed in this area.
				Ensure search and rescue and casualties receive attention.	First Aid team	
					Administration	Inc case of emergency – action plan and

				Administer first aid to the victim. Make arrangement to send injured person/s to Hospital. And inform victim's family. If off site emergency situation occur –Inform to following agencies. Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office.	team SMC	communication chart to be displayed in this area. Remaining benzene collection crude method of road tanker run forward and backward practices to be stopped immediately. Such crude method will lead road tanker disaster.
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TABLE: 7.19

HEAVY SPILLAGE OF ACID FROM STORAGE TANK

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Acid storage tank	Heavy spillage of ACID from Storage tank	(1) Heavy spillage of ACID in dyke area and due to contact with humid air and water contact with spilled material SO ₃ mist / fumes will be generated and travelled in down wind direction.	Over filling due to malfunction of level gauge and level transmitter. Bottom valve leakage Bottom line rupture. Puncher in tank wall	Raised alarm immediately for warning the people if large spillage observed. Do not enter in spillage area. Evacuate area in down wind direction up to 200 meter Call fire and Safety department for spill control Close valve immediately if it is safe to do. Cordon the area immediately. Stop all activities in tank farm area. Evacuate non essential persons from the affected area immediately. Try to control situation at department level with available resources with full PPEs. Identify the spillage material and refer MSDS for control plan. Inform the Site main Controller (SMC)	First observer/ driver/ cleaner/ operator All employees Operator Operator Operator Driver cleaner IC Rescue team Rescue team	High level indication shall be provided. High level cutoff shall be provided on storage tank. Integrity of the tank, pump and piping shall be checked regularly. Spill control plan to be prepared and training to be conducted to all operators. Emergency telephone number list to be displayed in this area. Incase of emergency – action plan and

				in detail. Take decision to Declare onsite emergency.	IC	communication chart to be displayed in this area.
				Efforts to be made to prevent spreading of ACID to a large area by containing it in a small area by temporary arrangements or by diverting the spreading liquid to a low lying area away from strategic plant areas.	IC	Neutralized material to be collect in close containers and disposed off in safe manner.
				Start to spread soda ash on spilled material to neutralize the ACID.	SMC	
				Ensure search and rescue and casualties receive attention. Administer first aid to the victim.	Fire and spill control team	
				Make arrangement to send injured person/s to Hospital.	Fire and spill control team	
				If off site emergency situation occurs – Inform to following agencies Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office	Rescue team	
					First Aid team	
					SMC	

TABLE: 7.20

DRUM SPILLAGE IN DRUM STORAGE AREA (SPILL CONTROL PLAN)

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Drum storage area	Small spillage Large spillage	Toxic vapour exposure to drum handling operators. Fire in case of ignition source available within LEL-UEL % concentration	Drum puncher or damage, wrong storage method.	Find out leakage drum Raised alarm immediately for warning the people if large spillage observed. Do not enter in confined room if spillage in room. Do not touch any electrical switches in spillage area. Stop all hot work in this area. Call fire and Safety department Cordon the area. Evacuate non essential persons from the affected area immediately. Inform the area in charge. Try to control situation at department level with	Incident controller IC IC IC and department team IC Security team Non-essential workers IC IC	1. FLP type light fittings provided. 2. Proper ventilation is available in Drum storage area. 3. Proper label and identification board /stickers is provided in the storage area. 4. Conductive drum pallets are provided. 5. Drum handling trolley / stackers/fork lift are used for drum handling. 6. Separate dispensing room with local exhaust and static earthing provision is available. 7. Materials are stored as per its compatibility study and separate area is available for flammable, corrosive and toxic chemical drums storage. 8. Smoking and other spark, flame generating item are banned from the Gate. 9. NFPA labels are provided on drums for hazard identification of

				available resources with full PPEs. Identify the spillage material and refer MSDS for control plan. Segregate leakage drum from the area. Inform the Site main Controller (SMC) in detail. Open all doors and windows in this area. Take decision to Declare onsite emergency Spill control and neutralization team member try to control spread material in more area by absorbing material and dry sand. If material is toxic or any other flammable and toxic chemical, special precautions needs to be taken as per chemical expert Key person guide line. Do not spray water or Foam on spilled material. Do not drain spilled material in any trench. Collect the spilled material in close container and send for ETP for further neutralization of the residual contents. Ensure search and rescue and casualties receive	IC Dept. Toxic control team IC Dept. Toxic control team SMC Toxic/Spill control team Toxic/Spill control team Fire team Toxic/Spill control team Toxic/Spill control team Rescue team First Aid team	the chemicals. 10. Exhaust is provided at ground level in drum storage area. 11. Drum loading unloading procedures are prepared and implemented.
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				attention. Administer first aid to the victim. Make arrangement to send injured person/s to Hospital. If off site emergency situation occur –Inform to following agencies, Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office	Administration team. SMC	
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TABLE: 7.21

FIRE IN DRUM STORAGE AREA

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Drum storage area	Small spillage Large spillage	Fire in drum storage area BLEVE of drums	Drum leakage or damage, wrong storage method. Ignition source like electrical source, Friction etc. BLEVE due to Metal drum heat in fire.	Raise fire siren or shouting Fire...Fire....Fire... Evacuate the area immediately. Inform the area in charge. Inform IC in detail. Call fire department immediately and help them for firefighting. Try to control situation at department level with available resources with full PPEs. If it is found uncontrollable condition by department level inform SMC for onsite emergency situation. Declare on site emergency if required. Remove un burned drums from the site if possible without any risk. Start fire hydrant system or water hose rill and spray water on uninvolved drums in fire for	First Observer All employees in this area First observer Department employee IC Department fire fighting team. IC SMC	1. FLP type light fittings provided. 2. Proper ventilation is available in Drum storage area. 3. Proper label and identification board /stickers is provided in the storage area. 4. Conductive drum pallets are provided. 5. Drum handling trolley / stackers/fork lift are used for drum handling. 6. Separate dispensing room with local exhaust and static earthing provision is available. 7. Materials are stored as per its compatibility study and separate area is available for flammable, corrosive and toxic chemical drums storage. 8. Smoking and other spark, flame generating item are banned from the Gate. 9. NFPA labels are provided on drums for hazard identification of the chemicals. 10. Exhaust is provided at ground

				cooling purpose. Use foam fire extinguishers for firefighting of fire. Do not enter in fire prone area. If fire found uncontrollable condition call fire brigade and mutual aider for help. In case of BLEVE fire, immediate evacuate the area up to 50 meters of the area surrounding. All hazardous activates stop at site. Inform nearby company to remove hazardous material or inventory from the compound wall. Ensure search and rescue and casualties receive attention. Administer first aid to the victim. Make arrangement to send injured person/s to Hospital. And inform victim's family. If off site emergency situation occur –Inform to following agencies. Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office	Rescue and evacuation team Fire team Fire team All team member SMC All team member SMC and all dept. head. SMC Rescue team First Aid team Administrati on team SMC	level in drum storage area. 11. Drum loading unloading procedures are prepared and implemented.
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TABLE: 7.22

THIONYL CHLORIDE DRUM SPILLAGE. (THIONYL CHLORIDE SPILL CONTROL PLAN)

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Drum storage area	Small spillage Large spillage	Toxic vapour exposure Evacuate area in down wind direction up to 327 meter	Drum damage, punctured, wrong storage method.	Raise siren or shouting for help Evacuate the area immediately. Inform the area incharge. Inform Incident controller (IC) in detail. Call toxic control team Try to control situation at department level with available resources with full PPEs. And respiratory system. If it is found uncontrollable condition by department level inform SMC for onsite emergency situation. Declare on site emergency if required. Inform nearby company to evacuate area in down wind direction. Coedon the area Do not entre in this area without respiratory protection and full body protection suite.	First observer All employees in down wind direction. First observer Area incharge Shift incharge IC Area incharge Shift incharge IC SMC SMC	1. Check for leakage all drums properly while unloading from truck. 2. If found any spillage first search for leakage drum. 3. Store separate from water source or reactive chemical drums. 4. Proper ventilation is available in Drum storage area. 5. Proper label and identification board /stickers is provided in the storage area. 6. Drum containment provision to be made. 7. Drum handling trolley / stackers/fork lift are used for drum handling. 8. Drum loading procedure to be

				Find out leakage drum. Remove spilled drum from the area in open place. Stop leakage if possible by drum position change. Transfer material from drum in a new drum by barrel pump or by gravity. Neutralize spilled drum by soda ash or soda lime powder . Spilled area to be covered and spray with soda ash or soda lime. Keep as it is for 1 -2 hrs. for neutralizing the TC. Collect the powder in close container and send ETP for safe disposal. Never use water for cleaning of TC spilled area. TC is water reactive chemical. It will generate SO₂ and HCL fumes and will create white fumes cloud in down wind direction. Ensure search and rescue and casualties receive attention. Administer first aid to the victim. In open air place. Make arrangement to send injured person/s to Hospital. And inform victim's family. If off site emergency situation occur –Inform to following agencies. Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office.	Security team All team members Toxic control team Toxic control team Toxic control team Toxic control team Toxic control team Toxic control team Toxic control team All team members Rescue team Fire team Administration team. SMC	prepared. 9. TC handling safety training to be provided to all operators. 10. NFPA labels are provided on drums for hazard identification of the chemicals. 11. Exhaust is provided at ground level in drum storage area. 12. Drum loading unloading procedures are prepared and implemented.
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TABLE: 7.23

SODIUM CYANIDE POISONING TO WORKER

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Sodium cyanide drum storage area	Toxic effect due to cyanide poisoning to workers	Fatality	Injection or oral dose due to contact with cyanide. Dust exposure during charging cyanide in to rector.	Symptoms may be delay after 3 to 6 hrs. if exposure low. Give first aid to victim. Apply Amyle Nitrate smell to victim by handkerchief. Apply Oxygen administration if he is breathing. After one minute repeat Amyle Nitrate treatment. This first aid treatment repeat till victim feel normal. Admit victim to hospital immediately. Cyanide Antidote Kit keep with hospital for intravenous injection by doctor. Apply Antidote injection Antidote kit is kept in office in first aid centre. Inform to statutory bodies.	First observer or victim. Train first aider for cyanide. Administration team First aid team By doctor only SMC SMC	1. Separate stored in locked room. 2. Away from water sources. 3. Total body protection suite is provided to charging operator with air line respirator. 4. Safe operating(Charging) procedure is prepared and displayed in process and storage area. 5. Total close process for charging and handling. 6. Antidote kit for cyanide is kept ready in OHC. 7. Training is being provided to handle NACN, 8. SCBA sets are available in handling area. 9. Operator having cuts and sores should not use cyanides. 10. If a little poisoning, inhale cyanide antidote kit (amyl nitrite, sodium nitrite and sodium thiosulfate) and oxygen for 15-30 seconds as first aid measures 11. Use sodium hypochlorite, calcium hypochlorite solution or potassium permanganate for washing balance,

				સાચવાર માટે એન્ટી-ડોટ કિટનો ઉપયોગ કરવાની રીત: સૌ પ્રથમ કિટમાં સમાવેશ થતી ચાર ગળીવાળી લોમી સોમોર્સલ નાઈટ્રેટ ની બોટલને મુકી ફરીથી ચાર ગળી વાળી બોટલ તોડી નાખી તે સમાવેશ થતી ચાર સંગ્રાહી તંત્રોમાં એક સીલનું સાથે રાખે એક મીનીટ બાદ ફરીથી સમાવેશ થતી ચાર સંગ્રાહી તંત્રોમાં એક સીલનું સાથે રાખે આમ જ્યાં સુધી માલસ નોર્મલ કંડીશન માં ના આવે ત્યાં સુધી કરતા રહે . માલસને હોસ્પિટલમાં લઈ જતી વખતે એડિતોનાઈટ્રેટ એન્ટી-ડોટ કિટ સાથે લઈ જાય અને હોસ્પિટલમાં હાજર ડોક્ટરને તે કિટ સમજાવી જરૂરી છે જેથી તે કિટની મદદથી ડોક્ટર સાચવાર કરી શકે. નોંધ: * એન્ટી-ડોટ કિટ સોડિયમ અને સાહેબની એડિસ માં સખામાં આવેલી છે.		glass apparatus, spatula, workplace and in case of spillage 12. Use Apron, eye protecting glass, Mask and gloves during transferring, work-up and decomposition of chemicals. 13. Issued quantity will be used fully for reactions. Can not be stored in the process area 14. Separate Log Book for issuing above cyanides and Manager has to sign on the register
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TABLE: 7.24

BROMINE BOTTLE DAMAGE SPILLAGE SCENARIO

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Bromine 3 kg bottle damage spill	Spill pool evaporative	Toxic fumes release in down wind direction at LC 50 , IDLH & TLV concentration	Health effect to nearby vicinity people	Raised alarm immediately for warning the people. Call the emergency response number (Area incharge) Evacuate non-essential persons from the affected area immediately.	First observer Incident Controller (IC) Non-essential workers	

		n	Try to control situation at department level with available resources. 1. As an immediate precautionary measure, isolate a bromine spill and leak area in all directions for at least 60 meters. 2. Consider taking steps to protect people downwind of the bromine spill through evacuation. For daylight hours the protection can extend up to 0.6 km downwind from the spill. During night-time the protection zone can extend up to 1.8 km. 3. Only trained chemical emergency responders should be allowed to clean up the spill. 4. Professional responders should always wear correct personal protective equipment when dealing with a bromine spill. 5. Neutralising chemicals should be in small quantities incrementally as needed (i.e - do NOT dump large amounts of neutralising chemicals onto spilled bromine all at once). 6. Wash the container afterwards using a brush and neutralizing solution followed by a water rinse. Inform the Site main Controller (SMC) in detail. Declare onsite emergency Barricade and restrict movement in affected	IC Department Toxic control trained team. IC and department team SMC Toxic team Fire and toxic	
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			area. Provide Mayur curtain in down wind direction to restrict dispersion. Spray Dil. Ammonia solution on gas cloud of bromine vapour OR Spread Sodium thiosulphate powder on liquid chlorine spillage. Ensure search and rescue and casualties receive attention. Administer first aid to the victim. Make arrangement to send injured person/s to Hospital. If off site emergency situation occur –Inform to following agencies Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office	control team Fire and toxic control team Fire and toxic control team Rescue team First aid team First aid team SMC	
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TABLE: 7.25

HYDROGEN CYLINDER CHARGING LINE FAILURE / POINT SOURCE RELEASE SCENARIO

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Hydrogen cylinder storage shed	Puff release from Hydrogen cylinder	Toxic release in down wind direction at LC 50 , IDLH & TLV concentration Fatality to human up to 125 meter Immediate danger to life and health(IDLH) Distance 648meter i.e Evacuation area Safe	Over pressure due to temp. increase Reaction in tonner with incompatible material. Over filling of Hydrogen Explosion due to cylinder involved in fire or IHR of fire.	Evacuate the surrounding area in factory premises. Raised alarm immediately for warning the people. Call fire and Safety department Evacuate non essential persons from the affected area immediately. Inform the area incharge Try to control situation at department level with available resources. Inform the Site main Controller (SMC) in detail. Start sprinkler system and Mayur curtain Take decision to Declare onsite emergency Shutdown the plant in safe manner Toxic control team members must wear air line respirator or SCBA set . Barricade and restrict movement in affected area.	Incident controller (IC) IC IC Non essential workers First observer IC and department team IC Toxic control team SMC IC Toxic control	• Stored in cool and dry place and PESO approved area. • Empty and filled cylinders are stored separately. • Hazard identification, control measures in case of leakage and first Aid procedure to be prepared and displayed at storage location. • On line AHCL Gas detector provided in storage area. • Cylinder store made well ventilated and safe distance maintained. • Sprinkler system provision made in cylinder storage area. • Cylinder leakage control Kit kept available at cylinder storage area. • Sprinkler point and Eyewash / Safety shower provided near cylinder filling point. • Special charging cabinet with blower provision made. Charging valve and weighing indicator fixed

		distance 6365 meter	Valve damaged	Ensure search and rescue and casualties receive attention. Administer first aid to the victim. Make arrangement to send injured person/s to Hospital. If off site emergency situation occur –Inform to following agencies Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office	team Security team Rescue team First aid team First aid team SMC	out side the cabinet. • Blower connected with HCL scrubber. • Auto cut off of charging of AHCL with weight interlocking provided. • Air line respirator and SCBA sets are provided in this area.
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TABLE: 7.26

MAJOR ELECTRICAL FIRE IN HT/LT PANEL, CABLE TRENCH, CABLE TRAY, ELECTRICAL EQUIPMENTS

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Plant area	Fire in panel, cable, cable trench, electrical equipments like motor, etc.	Fire	Electrocution and flashing due to short circuit or over load	Raise fire siren or shouting Fire...Fire....Fire...	First observer	1. Safety measures taken at design level and facilities installed as per requirements and electrical load. 2. Double earthing provided to all electrical equipments. 3. Rubber mat provided near electrical
				Evacuate the area immediately.	Non essential workers.	
				Inform the area in charge.	Department employee	
				Inform IC/ SHE Manager in detail.	Department employee	
				OFF electrical supply in fire porn area.	Electrical head	

				Call fire department immediately and help them for fire fighting.	Department employee IC/ SHE Manager	panels and switches. 4. All safety measures taken at design stage. 5. Mager test and earthing continuity test regularly carried out and log sheet maintained. 6. All electrical hazardous condition known to all concern dept. 7. Appropriate fire fighting arrangement is provided to control electrical fire.
				Try to control situation at department level with available resources with full PPEs.	Department fire fighting team.	
				If it is found uncontrollable condition by department level inform SMC for onsite emergency situation.	IC/ SHE Manager	
				Declare on site emergency if required.	SMC	
				Start fire hydrant system and spray water on fire.	Fire team	
				Do not enter in fire prone area. Due to toxic gas liberate in cable fire.	All team member	
				Remove combustible and flammable material from the fire site.	Rescue team	
				If fire found uncontrollable condition call fire brigade and mutual aider for help.	SMC	
				All hazardous activates stop at site.	SMC and all dept. head	
				Ensure search and rescue and casualties receive attention.	Rescue team	
				Administer first aid to the victim.	First aid team	
				Make arrangement to send injured person/s to Hospital. And inform victim's family.	Administration team	
				If off site emergency situation occur –Inform to following agencies. Request for Mutual aiders, local authorities like – DISH office, Collectorate office, Disaster management cell, Police, fire brigade, nearby hospital, local GPCB office.	SMC	

TABLE: 7.27

LEAK FROM FLANGES, VALVES, DURING TRANSFER FROM/TO MAIN TANK.

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Pipeline network	Spillage	Fire, spillage, corrosion, burn effect on human.	Gasket failure, corrosion, improper maintenance	Detect the source of leakage.	Maintenance team	Proper PMS system prepared and implemented.
				If the leakage is found significant then isolate branch of line & stop the flow.	Maintenance team	
				Stop the loading /unloading operation in the Tank	Maintenance team	
				Bring the portable fire extinguishers near to the area of leakage	Maintenance team	
				Ensure operation of the fire pump	Fire team	
				In case of major leakage follow action plan as per spill control plan.	-	

7.22.2 POSSIBLE EMERGENCY: - EARTH QUACK

TABLE: 7.28

EARTH QUACK

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whole plant	Earth quack	• Building, structure collapse, ground shaking, • Landslides, Liquefaction, • surface rupture	Natural calamities	Do not panic. Raise alarm.	First observer	Planning & Preparedness 1. Constitute Emergency Response Team 2. Identify control centers 3. Control centers to be equipped with 4. Communication facilities 5. Emergency vehicles/equipment 6. List of emergency contacts & suppliers 7. Medical facilities
				Evacuate building /plant immediately.	All employees	
				Avoid standing near to windows, external walls.	All employees	
				Stand near the columns or duck under sturdy furniture.	All employees	
				Assemble at emergency assembly point.	All employees	
				Take head count	HR dept. / SHE	
				Activate plant emergency plan as situation demands.	SMC	
				Assess situation and initiate shut down of plants (if required)	SMC and plant head	
				Initiate search & rescue (if required)	Rescue team	
				Provide first aid to victims. Remove casualties Key persons to report to site	First aid team	
				Assess damage	Key personals	
				Undertake restorative measures & repairs	Engg. Team	

7.22.3 POSSIBLE EMERGENCY: - FLOODS

Besides this, flooding of plants during monsoon due to clogging of storm water drains/ outlets may also take place. The plan to deal with floods can be divided in following stages:

TABLE: 7.29

FLOODS

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whole plant	Floods	- Flash Flooding, Flash, - River Flooding, - Burn Scars/Debris Flows, - Ice/Debris Jams, - Snowmelt, - Dry Wash, - Dam Breaks/Levee Failure	Natural calamities	Stop all field activities.	IC	Check 1. All storm water drains & outlets are cleaned & de-choked. Constitute 1. Plant Emergency Response Team comprising of (at least) one engineer, one HSE member, two operators & one Electrician. 2. Civil & Mechanical support team (including supply of spares). Maintain 3. Inventory of emergency items such as torches, ropes, lines, wire, tarpaulins, plastic sheets, tool kits, duct tapes, assorted gears & sand bags etc. 4. Food stock, water, blankets & bedding and medicines for distribution. Obtain & circulate 5. Advance forecast warnings to be continuously updated. 6. Mobilize emergency response team 7. Release non-essential personnel 8. Initiate shut down of plants(s) if required 9. Audit plant safety measures 10. Implement preventive & precautionary measures especially 11. Hot equipment to be cooled down. 12. Exposed machinery & equipment to be coated with grease. 13. Open flames should be extinguished
				Stop all permits to work.	IC	
				☐ Remain indoor observant to ❖ Detect any damage to equipment or buildings. ❖ Detect development of unsafe conditions. ❖ Maintain communication with Emergency Control Center.	IC and employees	
				Respond to emergency call		
				Audit plant area(s) for damage assessment Implement fire preventive measures undertake restorative measures & repairs Restart the plant (s)	Engineering team	

7.22.4 POSSIBLE EMERGENCY: - CYCLONIC STORMS / HURRICANE

Cyclonic storms/ hurricanes are intense depressions, which develop in tropical latitudes and are often the cause of very high winds and seas. The wind blows around the center of a tropical storm in a spiral flow inward, anti-clockwise in Northern Hemisphere and clockwise in Southern Hemispheres. Plan for tackling cyclonic storm/ hurricane can be broadly divided in following stages:

TABLE: 7.30

CYCLONIC STORMS / HURRICANE

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whole plant	Cyclonic Storms / Hurricane	- storm surge and storm tide, heavy rainfall and inland flooding, - high winds, - rip currents, - tornadoes	Natural calamities	Mobilize emergency response team	IC / SMC	1. Inventory of emergency items such as torches, ropes, lines, wire, tarpaulins, plastic sheets, tool kits, duct tapes, assorted gears & sand bags etc. 2. Food stock, water, blankets & bedding and medicines for distribution. 3. Implement preventive & precautionary measures
				Release non-essential personnel	IC / SMC	
				Initiate shut down of plants(s) if required	IC and employees	
				Stop field activities. Stop all permits to work.	IC	
				☐ Remain indoor observant to ❖ Detect any damage to equipment or buildings. ❖ Detect development of unsafe conditions. Maintain communication with Emergency Control Center.	Engineering team	

7.22.5 POSSIBLE EMERGENCY: - BOMB THREAT

All telephone calls and emails threatening harm to people or property, such as bomb threats, should be taken seriously.

TABLE: 7.31

BOMB THREAT

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whole plant	Bomb Threat	detonate an explosive or incendiary device to cause property damage, death or injuries		If the threat is by Email Contact immediately your site Security & Crisis Management Leader / EHS Leader or Emergency Response Team and report that you have received a threatening e-mail and also inform to global IT team.	E-mail receiver	1. Security system is provided. 2. CCTV camera provided in all areas of the plant. 3. Without photo ID no one can enter in premises. 4. Vehicles are checked at main gate thoroughly for suspicious material during entry of vehicle.
				1. Be calm. 2. Contact the C M Leader/EHS Manager/ IC/ Functional Leader if you have received the call and give all information regarding the call or Email. 3. Evacuate immediately through the nearest exit after hearing the alarm and announcement, 4. Shut down critical operation. 5. Do not disturb anything while evacuating. 6. Follow evacuation procedure and reach the designated assembly point. 7. Do not run or dash. 8. Keep the doors & windows open.	IC / SHE Manager and employees	
				WHAT TO DO IF YOU RECEIVE A BOMB THREAT ON YOUR TELEPHONE. Contact immediately your site Security & Crisis Management Leader		

				/ EHS Leader or Emergency Response Team and report that you have received a threatening Phone		
				Question to Ask: 1. When is it going to occur (or explode)? Where is the harmful item (or bomb) right now? 2. What kind of item (or bomb) is it? 3. What does it look like? 4. Why did you place the item (or bomb)? 5. Where are you calling?	Call Recipient	
				Things to note: 1. Apparent sex, age, and maturity of the caller. 2. Peculiarities of voice or speech 3. Speech impediment, foreign accent, regional flavor, signs of intoxication, irrationality, and “pet phrases,” or their mannerisms. 4. Listen for background noises	Call Recipient	
				What to do if...You observe Suspicious Behavior: 1. Description of the suspicious behavior. 2. Description of person(s). 3. Make/Year of vehicle (if applicable). 4. Color of vehicle. 5. License plate number and State. 6. Time 7. Vehicle’s location and/or direction of travel. 8. Vehicle in restricted areas without proper identification. 9. Passengers taking photographs or video of any part of the facility.	Observer	
				1. Inform Site Shift Manager & Security	Observer/ Call Recipient	

				1. Inform all personnel to provide information regarding any unidentified or suspicious objects/ persons	Observer/ Call Recipient	
				1. Intensify vigilance & patrolling	Security head	
				1. Initiate bomb search	Security head	
				2. If any suspicious object is detected, inform Police Commissioner for arranging bomb disposal squad	SMC	
				3. Make arrangement to minimize effects	SMC	
				4. Make arrangement for evacuation	SMC	
				5. Liaise with police	SMC	
				6. If bomb recovered/ no untoward incident occurs restore normalcy.	SMC	
				If blast occurs 1. Activate concerned plant(s) emergency plan – tackle fire/ toxic leakage/ structural collapse etc. Assess damage. 2. Take restorative measures. 3. Liaise with authorities (police, insurance etc.).	SMC	

7.22.6 POSSIBLE EMERGENCY: - INDUSTRIAL UNREST

Industrial relation between personnel and management may deteriorate because of any reason. Problems, which may arise due to industrial unrest, include:

Dharna/ Strike/ Hunger strike	Unofficial gatherings/ Gate meetings/ Forceful entry
Work to rule/ Go slow/ Disobedience	Gherao/ Rasta rook
Intimidation & Use of force	Support from local & criminal elements
Sabotage	

In such a scenario, to ensure smooth operation of plant(s), protection of lives and property, well-coordinated effort is needed from all concerned. Plan to deal with industrial unrest can be broadly divided in following stages:

TABLE: 7.32

INDUSTRIAL UNREST

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Whole plant	Industrial Unrest	Unofficial gatherings/ Gate meetings/ Forceful entry Gherao/ Rasta rook Support from local & criminal elements	Industrial Unrest	Any employee noticing or heard about the Civil Disturbance immediately call EHS / Security department to give the information.	First victim	--
				Don't allow to enter any unknown person in the site	Security team	
				Strengthen security at sensitive points	Security team	
				Ensure protection lives & property	Security team	
				Intensify vigilance & patrolling	Security team	
				Assemble in designated Safe Assembly point.	All employees	
				Brief to Site main controller and Crisis management Leader.	First victim	
				Join your group at assembly point and present yourself for headcount to head count coordinator.	All employees	
				Communicate to ECC/Emergency team for missing or trapped employees.	Victim /IC	
				Give this information to site main controller/ EHS dept./ Manufacturing Head.	Victim /IC	
				Maintain law & order	SMC	
				Ask help form nearest police station.	SMC	
				Assess damage (if any)	SMC	
				Restore normalcy	SMC	

7.22.7 POSSIBLE EMERGENCY: - LIGHTING STRIKE IN COMPANY

TABLE: 7.33

LIGHTING STRIKE IN COMPANY

Location	Scenario considered	Hazard Consequence	Possible Causes	Action to be taken	Action by	Remedial measures to prevent recurrence of such incident
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Building roof	Lighting strike in company	Fire, burn effect on human.	Natural	Immediate evacuate the affected area of the plant.	All employees	Proper PMS system prepared and implemented.
				In case of burn injury to any person, rescue the victims immediately from the plant at any safe location.	Department emergency team member	
				In case of fire in the building/ plant follow fire emergency action plan.		